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E-19-612



PROCEEDINGS OF THE GEORGIA TECH FORUM FOR THE
NATIONAL COMMISSION ON MATERIALS POLICY

TOPICS – MATERIAL DETERIORATION, CONSTRUCTION MATERIALS,
TEXTILES AND FORESTRY AND FOREST PRODUCTS

EDITOR: R. F. HOCHMAN

Proceedings of the Georgia Tech Forum for the

National Commission on Materials Policy

Topics - Material Deterioration, Construction Materials,
Textiles and Forestry and Forest Products

Conference Chairman, R. F. Hochman,
Professor and Associate Director for Metallurgy,
School of Chemical Engineering,
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October 1972

ABSTRACT

This report covers the proceedings and deliberations at the Georgia Institute of Technology Forum for the National Commission on Materials Policy. The purpose of the Forum was to provide the educational community, in concert with industrial and governmental personnel, an opportunity to discuss four extremely important facets of national materials policy. The report includes the full text of the formal presentations and the workshop reports in the areas of materials deterioration, transportation and construction materials, natural and synthetic textiles, and forestry and forest products. An objective review of the Forum deliberations is contained in the Summary starting on page 152. The Forum was held at the Georgia Institute of Technology June 26-28, 1972.

REMARKS

The material contained in these proceedings represents the thoughts of the authors and the consensus of opinion of the individual workshops. This material is in no way to be construed as final recommendations of the National Commission.

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THE BACKGROUND AND PURPOSE OF THE GEORGIA INSTITUTE OF TECHNOLOGY FORUM FOR
THE NATIONAL COMMISSION ON MATERIALS POLICY

by

Robert F. Hochman
Professor and Associate Director for Metallurgy
School of Chemical Engineering
Georgia Institute of Technology

The National Commission on Materials Policy was established under Title II of the Resource Recovery Act of 1970:

"It is the purpose of this Title to enhance environmental quality and conserve materials by developing a national materials policy to utilize present resources and technology more efficiently, to anticipate the future materials requirements of the Nation and the World, and to make recommendations on the supply, use, recovery, and disposal of materials."

The University forum programs of the Commission provides the academic community an opportunity to contribute their views on a national materials policy. This meeting is one of eight to be held in the country. It deals specifically with materials degradation and deterioration (including recycling and controlled degradation), synthetic and natural textiles, transportation and construction materials, and forestry and forest products. An extension of this program will later evaluate the basic needs of materials in dental-medical applications.

The program topics were chosen, first on a basis of national need, and secondly, on a strong regional involvement, i.e., textiles and forestry and forest products. An extension of this program will later evaluate the basic needs of materials in dental-medical applications.

The program topics were chosen, first on a basis of national need, and secondly, on a strong regional involvement, i.e., textiles and forestry and forest products. Figure 1 provides a general outline of the deliberations, showing the interaction of areas of concentration with a broad range of national and international considerations, all of which must be evaluated and summarized to develop fundamental policy to be presented to the Commission.

To provide the proper perspective for discussion, a few major issues will be presented. From this, it will be obvious that important national policy is needed in many areas of deliberation.

I. MATERIALS DEGRADATION AND DETERIORATION (CONTROLLED DEGRADATION AND RECYCLING)

The extensive costs of corrosion and materials degradation has been emphasized by virtually every author who has attempted to examine this problem. Unfortunately, it still is not considered by managerial personnel as other than a normal maintenance and/or attrition problem. However, the true cost of materials deterioration cannot be evaluated monetarily based on replacement and maintenance. The tremendous direct losses involved annually in the United States exceeds \$15 billion in metallic corrosion alone and no precise figure on the degradation of many other materials, i.e., concrete, polymers, asphalt, wood, etc. is available. Even though as astounding as this figure is it has still not brought the proper examination of this attrition of our natural resources plus the secondary economic losses due to contamination of products, accidental damage and injuries, long periods of down time and lost production, and the large contribution to the pollution of our environment.

In recent years the National Association of Corrosion Engineers and a group of university professors have been able to evaluate numerous corrosion losses and pinpoint their cause to the selection of improper materials, inferior materials, and most of all, a lack of knowledge of the basic corrosion principles which would eliminate more than 1/3 of the direct corrosion losses each year. This savings compared to the gross national product could be as high as 2%. Certainly the problem is of paramount significance to a national policy in materials. We must not only look at the national needs in raw materials but we must look at their protection, conservation and safety when they are interfaced with personnel and the environment. Table I provides a list of some of the discussion areas which are to be covered in the workshop in this area.

II. TRANSPORTATION AND CONSTRUCTION MATERIALS

An extremely broad range of construction and transportation materials problems presently exist, i.e., the shortage of brick and the shortage of cement, the latter a result of the closing of a number of facilities because of environmental pollution and the price freeze occurring at the time of a price war making production costs in many plants unprofitable.

It also has been judged that 50% of our present bridges are serving beyond their normal safe life and load carrying capacity. What is to be done in evaluating and reworking such structures as well as the designing and building of better and newer structures is extremely important. Other problems are the evaluation of pre-stressed concrete in engineering applications, the availability of gravel and rock for highway surfacing, etc., must be discussed. A preliminary work sheet for the most prominent areas for discussion in transportation and construction materials is provided in Table II.

III. SYNTHETIC AND NATURAL TEXTILE MATERIALS

The textile industry employs nearly one million people in the United States. It is, as we know, under pressure nationally in certain areas due to labor and manufacturing costs and foreign supply. A strong look at the inner-relation of the import-export market of synthetic and natural fibers has to be made on the basis of national needs and national goals. It appears that highly technical textile industry is competitive. Those companies with large research groups have successfully countered the trend in the industry and in certain cases have shown excellent growth, exceptional new products and maintained an excellent corporate balance sheet. However, how can we help the many small companies that cannot compete either in new products or new methods of producing standard products?

Another area to be discussed is the importance of textile equipment. Production and design of textile equipment in this country has decreased to a point where nearly all equipment now comes from foreign suppliers. A review of how, why and what we can do about this problem is important, particularly if we are to help the small producers in developing new technologies. We must also consider our overall dependence upon foreign technology for new methods of textile production. Table III provides some basis for initial discussion within the workshop on synthetic and natural textiles.

IV. FORESTRY AND FOREST PRODUCTS

The increased demand for paper products, the increase in housing requirements (lumber and associated building materials), the needs for cellulose and wood by-products, etc., all point up the significance of a national policy in forestry and forest products. There is a major waste in forestry, slash, which is basically 40% of the tree; it remains in the forest as a non-usable material after cutting. Evaluation of economic and beneficial use of slash is important not only to better utilization of our forests but certainly to the improvement of our environment. The many wood product needs make it important that we consider the total reforestation in the country so it may continue serving the needs of the nation. Because of the increased sophistication in forestry, a whole new concept, forest engineering, is being developed which deals not only with the basic planting and maintenance of trees but the harvesting, transportation and product development. The need for interdisciplinary action between forestry and engineering must be assessed in this area. Table IV provides a series of points of discussion for the workshop in forestry and forest products.

A fifth area will also be discussed at a later time.

V. MEDICAL-DENTAL MATERIALS

One of the most unique areas of materials application is in the medical environment. Dental usage of metals has a broad historical background and today over two billion dollars per year is spent on dental care involving the use of dental amalgam which certainly relates to the need for silver, tin and mercury. Important to the new medical uses is the consideration of materials for orthopedic implants, organ replacements, electrodes, etc. In fact, the government is now looking at FDA regulations of medical implants as drugs, but certainly the aspects of metals in the body have other functions than strictly as a drug consideration. Medical materials on an international basis is also important; at the moment there is no federal backing, financial or even moral support, for the people who have been working in international deliberations to set up standards and review basic requirements for medical-dental materials. Further, a thorough evaluation of the sophisticated needs and interaction at the biological-materials interface is obviously beyond the capabilities of the small industries involved in the area. Therefore a combination of government and education must provide the strong assistance to expand this important area of human need.

As you can see, our task is enormous and from the academic standpoint it is for us to provide leadership in evaluating future trends, educational requirements and research productivity to assist in the evaluation and presentation of significant policy statements to the national commission.

Areas of Concentration	Statistics, Projections, Requirements, Areas to Develop, Etc.							
Materials degradation and deterioration (recycling in certain cases)	National Goals	Needs and Requirements	Technology and Engineering	Education	Manpower	Research	Environmental and Pollution Effects (Ecology)	Economics
Transportation and Construction Materials								
Synthetic and Natural Textiles								
Forest Products								
* Medical Materials								

POLICY

* Special sub-program not included in regular symposia schedule.

FIGURE 1. Schematic diagram of the interaction of materials area with factors influencing materials policy.

TABLE I

WORKSHOP I--MATERIALS DETERIORATION

Topic for Discussion

- A. Depletion of Materials Resources (need for replacements)
 - B. Product Design (materials selection, product liability, consumer protection)
 - C. Product Obsolescence (corrosion, loss of utility, etc.)
 - D. Product Hazards (flammability, pollution)
 - E. Materials recovery and reuse (separation, processing, applications)
 - F. Education and Manpower (level and type of training, concepts, information transfer)
 - G. Research (fundamental needs, technological advances and competition)
-
-

TABLE II

WORKSHOP II--TRANSPORTATION AND CONSTRUCTION MATERIALS

Topics for Discussion

- A. National Goals
 - 1. Preservation of Natural Resources
 - 2. Selective Utilization for Public Benefits
 - 3. Reclamation
 - B. Needs and Requirements
 - 1. Projections for Short and Long Term
 - C. Technology, Engineering, Research
 - 1. Efficiency in Utilization
 - a. Local Materials
 - b. Marginal Materials
 - c. Quality Control
 - 2. Materials Benefication
 - 3. New Material Development
 - 4. Recycling, Reusing, etc.
 - D. Education
 - 1. Materials Resources Centers
 - 2. Materials Resources Management Studies
 - 3. Materials Engineering
 - 4. Materials Science
 - E. Environmental Aspects
 - 1. Air and Water Pollution
 - 2. Noise Abatement
 - 3. Esthetics
 - 4. Recreational
 - F. Legal
 - 1. Private Enterprise--Government Control
 - 2. Eminent Domain
 - G. International
 - 1. Requirements for Imports
 - 2. Location of Sources
 - 3. Treaties
-

TABLE III
WORKSHOP III--SYNTHETIC AND NATURAL TEXTILES

Topics for Discussion

- A. Needs and Responsibilities of Textile Education
 - B. The Role of Government in Textile Research
 - C. Technical Needs and Requirements for Textiles
 - D. Growth Limiting Factors in the Textile Industry
 - E. Legal and Ethical Responsibilities of the Government and the Textile Industry
 - F. The Role of Government in the Regulation of Textile Imports
 - G. The Role of Textile Research in the Future of the American Textile Industry
 - H. Textile Machinery, a Dead Industry in the U. S.
-
-

TABLE IV
WORKSHOP IV--FORESTRY AND FOREST PRODUCTS

Topics for Discussion

A. Material Requirements and National Goals

1. What is the best source for defining raw material requirements over the next 25 years? 50 years?
2. What conditions or present national goals tend to discourage the development of forest product industries?
3. To what extent will increased productivity in forest product industries match increasing material requirements?
4. To what extent should Government subsidize the production of forest raw materials if foreign competition is not offset by increasing domestic productivity?
5. Will technological changes in the construction industry substantially alter the need for forest products?

B. Technology Requirements and Research Goals

1. To what extent should Government foster applied research and development programs in forest product industries?
2. What role should Government play in stimulating domestic private investment in new technology in forest product industries?
3. What types of incentives are needed to increase and redirect private research and development programs in forest product industries?
4. How do we stand in research and development regarding forest raw materials when compared to foreign programs (Scandinavia, Soviet Union, etc.)?

C. Manpower Requirements and Educational Goals

What manpower problems confront the forest product industries as related to:

1. Shortage in in-woods labor?
 2. Shortage of skilled labor as mechanization of growing and harvesting systems increases?
-

TABLE IV continued

-
3. Lack of technical educational programs to relieve shortages in 2 above?
 4. Role of Government, organized labor, and management in training programs to relieve shortages in 1 and 2 above?

D. Social Requirements and Environmental Goals

1. What is the future regarding recycling of cellulose fiber products?
2. Can research in sorting, collection, transportation, and reuse of used forest products alter 1 above?
3. Does Government have a role in promotion of 1 and 2 above?
4. Can private reforestation programs satisfy social confrontation over the reduction of domestic forested areas?
5. Should Government take any action regarding the increase of domestic forested areas? If so, what action?

E. Economic Requirements and International Goals

1. To what extent will import of forest raw materials alter our domestic policies?
 2. To what extent will low cost foreign labor force industry consideration of 1 above?
 3. To what extent will wholly manufactured foreign forest products economically compete with domestic products?
 4. Will taxation policies regarding forest lands reduce private investment levels in forest lands?
 5. Will activities by Government in 4 above, substantially change the harvesting cycle in forest product industries?
-

THE ASSESSMENT OF MATERIALS LIMITATIONS AND

RECOMMENDED COURSE OF ACTION

by

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International Nickel Professor of
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INTRODUCTION

I wish, first, to commend The Policy Commission on Materials Policy on the bold adventure outlined in their April 1972 report, "Towards a National Materials Policy--Basic Data and Issues--An Interim Report." Not only does their conception of the problem embrace a suitably broad preview of the problem but they have managed to involve all the significant sectors of the economy. Further they have approached the problem as honest seekers of information in the service not only of the United States but of humanity in general. Also, it is appropriate for us to set our own house in order before someone else does for us.

Quoting from the legislation which set up the Commission in October 1970 the general objective of assignment of the Commission is as follows:

It is the purpose of this title to enhance environmental quality and conserve materials by developing a national material policy to utilize present resources and technology more efficiently, to anticipate the future materials requirements of the Nation and the world, and to make recommendations on the supply, use, recovery, and disposal of materials.

We have at The Ohio State University been concerned with the environmental stability of engineering materials for many years. We have worked both in the areas of research and education. In our research we have covered the broad range of destructive phenomena in engineering materials. In education we have produced movies, conducted lecture-laboratory programs for industry and government personnel, conducted individually tailored programs for industrial personnel on leave, and offer a broad program of education for graduate and undergraduate students.

Accordingly, I wish to offer comments on the objectives, conception of the problem, and implementation of the objectives. Like the April 1972 report

of the Commission my suggestions are interim ones and certainly can stand the maturing associated with exposure and criticism.

OBJECTIVES

Introduction

The essential objectives of the April 1972 report are concerned with long term availability of resources and the quality of the environment. I wish to propose that PUBLIC SAFETY AND RELIABILITY OF MATERIALS be incorporated as a third major component and that PROPERTIES OF MATERIALS AND THEIR ENVIRONMENTS be a fourth major component.

"PUBLIC SAFETY AND RELIABILITY OF MATERIALS" as an Additional Objective

While premature failure of materials is a well known phenomenon to the specialists, the apparently innocuous conditions under which even the "space age" materials fail seems incredible to the laymen. Many of these failures involve a number of inextricably related causes including poor design practice, carelessness, lack of capacity to inspect incipient failure in time for prevention, lack of information as well as inherent weakness of the material.

To emphasize this concern I have cited below a number of instances of failure or types of premature failure which have occurred:

1. Pipelines carrying natural gas have exploded and the fracture run several miles before arresting. The 1965 pipeline accident in Natchitoches, Louisiana killed 17 persons. As a result of this failure, the Federal Power Commission compiled statistics concerning failure for the period January 1965 to June 1965. These statistics revealed a total of 2294 failures in which 64 persons were killed and 222 injured.

2. Bridges fail such as the case of the Silver Bridge across the Ohio River at Point Pleasant, West Virginia where 46 persons were killed. The failure was caused by some combination of increased operating loads, noxious industrial environments, and poor design.

3. High speed power turbines explode such as the case for Hinkley Point in the United Kingdom by a combination of temper embrittlement and stress corrosion cracking.

4. Tank trucks carrying anhydrous ammoniac fail by stress corrosion cracking.

5. In the human body, metal devices fail including pacemakers and metal implants for bone repair.

6. In the United Kingdom the Comet jet liners and in the U.S. the Electras failed for reasons of fatigue.

7. In the U. S., as well as in the countries of our allies and various enemies, military equipment has been inoperative as much due to materials defects as to military usage. Condenser failures in the United Kingdom during WWI, stress corrosion of German submarine hulls in WW II, and stress corrosion of missiles and aircraft components during the past years in the U. S. are appropriate examples.

8. The failure of the welds in the bottom of the nuclear power plant at Oyster Creek, New Jersey, cost a rumored \$50,000,000 in repair costs plus a non-availability of power for over a year.

9. From 1942 to 1952 approximately 250 ships experienced fractures that weakened the main hull structure so that the vessels were lost or in a dangerous condition; 19 of these ships broke completely in two or were abandoned after severe cracking.

10. Failure of dams has contributed extensively to loss of life. The Malpasset concrete dome-shaped dam near the French Riviera failed in 1959 killing 421 people. This dam was constructed using best techniques available but the engineers had overlooked the significance of a thin clay seam which nucleated the instability.

Thus, the safety and reliability of engineering materials is a direct concern to the well being of all people. A concern for this area must, therefore, be implicit in the objectives of the Commission.

"PROPERTIES OF MATERIALS AND THEIR ENVIRONMENTS" as an Objective

Improved utilization of materials depends very much on our understanding of their properties. Further, the property of a functioning material depends greatly upon its interaction with its environment. Both the materials and environments need, first, to be conceived in their broadest possible ramifications.

Engineering materials include the solid, gaseous, and liquid states. Solids are used for enormous varieties of structural purposes as well as for their intrinsic physical properties. Gases and liquids are media for chemical processing, heat transfer, destructive corrosion, lubrication, ambients, buoyancy, etc.

Solids must include the broad range of metals, glasses, ionic solids, rubber, polymers, fibers (natural), natural rock, earth (including clays), aggregates, composites, etc.

Properties of rock are of interest, for example, in view of earthquakes,

rock drilling, mining, underground habitations, tunnels, foundations, underground circulation of water, and the extraction of geothermal power. Properties of earth components (sand, clay, topsoil) are important in view of interests from earth slides, agriculture, dam failures, surface and drainage of water.

Properties of interest extend from some of the usual, and perhaps mundane, to the more exotic. Mechanical properties, free energy of formation, thermal expansion, multicomponent equilibria, heat transfer, and structure are perhaps among the less exotic. Super conductivity, magnetic properties, optical properties are among the more exotic. But all are important.

Knowledge of such properties enables establishing whole new industries as well as predicting with better assurance the behavior of existing systems.

In view of our current interests in biological systems, knowledge of properties of organic material (animal and vegetable) comes within the set of materials and environments.

It is time also that we learn to consider our environments on a broader scale. While gases and liquids usually are considered as environments, other important environments include: neutron fields, X-ray and gamma-ray fields, magnetic fields, electrical fields, stresses, sunlight, etc. Each of the environments in the set implies both constructive and destructive components. Sunlight, for example, embrittles polymers, but also supplies useful power.

CONCEPTION OF THE PROBLEM

Introduction

It is my understanding that the Commission wishes to consider materials in the broadest possible way. Accordingly, I wish to suggest that the Commission consider the following. No doubt many of these are already under consideration and I wish only to re-emphasize their importance.

World Population and Increased Standard of Living as a Major Pressure for Consumption

The April 1972 Commission report clearly recognizes the increased rate of consumption of the other countries of the world as their standards of living increase. Regardless of the vagaries in forms of government, people will continue to press for more consumption such that in the not-too-distant future there will be little recognizable difference in consumption rate of all peoples. The question is simply a matter of rate of rise. Table I emphasizes the potential pressures for consumption of materials and energy.

While any estimate of the time to achieve equal per capita incomes throughout the world is a matter of "educated guessing," it must be quite clear that this will occur.

It is unfortunate but true that the most populous countries are those having the furthest to go and consequently they will exert the greatest pressure. Processes at work which will assure this equilibration are the following:

1. High speed optical and voice communication is accessible to the entire world.

2. Transportation of large numbers of people to any part in the world can be easily performed in 24 hours or less.

3. Transportation of small tonnage quantities of goods can be performed in 24 hours or less.

4. Very large quantities of bulk goods can be transported to anywhere in the world in less than three weeks.

5. Superhighway development has been completed (major network) in the U.S. This technology and coverage will certainly cover all countries in the next century.

6. The technology for transmission of goods by pipeline is well developed and spreading.

7. The technology for transmission of electrical power is well developed.

8. Multinational corporations are now firmly entrenched and emanate from all the major industrial countries to virtually every country in the globe. Multinational corporations now produce 450 billion dollars in goods and services per year outside the countries in which they are based. Of this, U. S. companies account for 220 billion dollars.* U. S. investment in Spain alone is now 700 million dollars.** Ford Motor Company just earmarked \$150,000,000 for a Maverick engine plant in Brazil.*** An \$8,000,000 Ford plant is now being built in Africa, to be completed in 1974, to produce 6000 cars and trucks per year. GM is building a similar plant.****

9. The high-speed computer has obviated the need for trivial activity by humans and has increased our capacity to consider complex issues.

10. Sophisticated guidance systems and technology permit navigation in terrestrial and extra-terrestrial regimes with confidence.

11. Interactive communications for distances as far as Mars is possible and one way radio contact with distant stars is possible.

* Fortune, December 1971.

** U. S. News and World Report, January 31, 1972.

*** U. S. News and World Report, March 20, 1972.

**** U. S. News and World Report, June 12, 1972.

12. The ultimate in destructive force as well as delivery systems are now available. Both the nuclear explosive and the high wattage laser beam supply the once imagined super explosive and the death ray.

The materials situation is thus succinctly summarized from Buckminster Fuller in his Ideas and Integrity. He notes that if the world's population took as a birth-right the same per capita amount of copper as have the citizens of the USA, then even the most optimistic estimates of the world's copper resources would be completely depleted.

Steady States in Materials Recyclability and Power Consumption

Most of the data in use today for describing materials consumption are given in terms of one cycle use. The concept of Steady State Recyclability outlined by Fuller should become a standard part of our materials jargon. Thus, we need some basis for determining how much new and irreplaceable material will be consumed and how much can be recycled.

Such an approach would emphasize and place increased pressure on recyclability. The optimum situation, of course, is not to require any irreplaceable resource of material but simply to use those which can be continuously recycled.

The ultimate goal of this consideration is a new Technology of Recyclability.

The analogous steady state in the area of power is to use only power from the sun. This objective may be more elusive but ultimately will be absolutely necessary.

This general concept implies using materials which may be uniquely suited for specific applications. For example, while copper is uniquely suited for use as an electrical conductor, it is absolutely not essential for the miles of tubing in corrosive heat transfer systems. Iron is certainly not absolutely necessary for a majority of automobile parts as it is not for many appliances. Polymers, glasses and their composites would be adequate for those cases involving shape and esthetic purposes.

An important part of this Technology of Recyclability is optimization of the energy required for recycling and the polluting processes involved therewith.

IMPLEMENTATION

Introduction

The April 1972 Commission Report includes an important section on "Materials Issues and Problems." The purpose of my discussion here is to

suggest approaches to some of the questions raised and to suggest other issues and problems. The point of view taken here is both that of an educator and as one concerned with the chemical and mechanical stability of materials.

Critical to much of the discussion which follows is a concern for the effective development and transfer of information. For example, engineers understand and use little of what science develops. The layman understands very little of technology. The scientist is often unresponsive to societal needs. The individual has little intuitive appreciation for the universe of which he is a small part.

The suggestions which follow are, to a large extent, miscellaneous and are in no sense complete answers; nor do they completely cover the "Materials Issues and Problems" of the 1972 Commission Report.

Substantial Improvement in Effectiveness of Educational Delivery Systems

In the context of this meeting, major concerns are productivity of individuals, their development as people, and their intuitive acceptance of the total world problem of the balances among materials, energy, and environmental consideration.

More research, alone, is not nor never has been a suitable answer, despite our persistent proclivity for such a solution.

Nor is education the only answer. However, such an approach may open enormous resources of talent not hitherto available.

Those engineers in the business of analyzing failure will quickly tell those who would listen that a very small percentage of failures occur for reasons requiring more research.

A frequent complaint of technologists is "When I was in college I didn't appreciate the value of what I learned and when I started to work I didn't have time to learn what I needed."

A sidelight in the interaction of education and technology concerns Admiral Rickover's approach to the developing nuclear power. He knew that reactors would never be completely without problems. Therefore, he instituted an approach to educating atomic energy personnel which imbued them with a hyper-sensitivity to possible problems. Probably a major portion of the present success record and advances in the technology owes itself to Admiral Rickover's perspicacity in this regard.

Listed below are a number of suggestions and observations concerning the effectiveness of education--whether it applies to the problem at hand or to others.

1. Education is not available in packages which are sufficiently effective or available for the technologist. In view of the vagaries of

schedules the technologist cannot always attend a formal series of lectures either at his company or at a nearby institution. Further, the entire course may not be necessary for the needs of the technologist. Books also, by themselves are not adequate. Basically, we need to develop automatic and flexibly available educational modules which involve sound and visual information preserved in a well illustrated and kinetic fashion. Furthermore, such a package needs active participation.

2. There is insufficient manual or laboratory involvement of the learners in the teaching-learning situation. Most short courses leave out the direct laboratory participation owing to the difficulty. Lectures alone without direct participation for the technologist are close to useless.

3. There is very great competition from other media. Educators should be geared to compete with the effectiveness of other media which compete for the attention of the learner.

4. Most education is too abstract. We need enormous improvements in our visual materials showing the broad qualitative significance of phenomena.

Need to Establish National Subject Area Laboratories With Composite Scientific-Engineering-Educational Missions

To a very large extent our scientific and technological development has been very haphazard and very wasteful. Partial precedents for the suggestions in this section are seen both in Germany and the USSR. However, the existing deficiencies in their systems do not advance them beyond the USA from a point of view of effectiveness.

The essential concept here involves the development of very strong central facilities which have national responsibility for specific subject areas. The laboratory mission would involve the basic science, engineering development, and educational aspects of an area. Principal characteristics of such laboratories would include the following:

1. Basic science from all fields would be assessed for its relevance to possibly significant technological developments by scientists capable of "bridging the gap." This would develop a generation of "gap bridgers" who have the scientific talent but the engineering appreciation.

2. They would be constantly summarizing, evaluating, focusing the area, and consolidating gains.

3. They would take responsibility for dissemination of information through courses, movies, lectures, monographs, etc.

4. They would coordinate national and international efforts.

5. These facilities would be budgeted for sufficient external research so that individuals at private research organizations, universities or even

other institutions would be funded. The central facility would not eat up all the funds but would actively encourage outside investigation.

6. These facilities would now serve as authoritative centers for industry consultation.

7. They would serve as a long term thread of technology.

8. Educational tools would be developed which would most effectively transmit and elucidate ideas.

9. Some of these institutions would overlap if necessary.

10. Each institute would be associated with a major university facility. Students would be employed at the undergraduate, graduate, post doctoral and industrial levels, so that they can carry the message continuously to the many parts of industry and the world.

11. Each faculty would have a backbone of interdisciplinary personnel competent in peripheral and directly relevant areas. Also, specialists in educational and information technologies would be included.

12. The great cry for "immediate breakthrough" would be sublimated to the general plan for substance and solid and useful advances.

Areas in which such programs might be considered in the area of materials are the following: Physical properties of solids, machining of solids, non-destructive evaluation, chemical stability of solids, joining of solids, recycling of solids, lubrication and wear, fabrication processes, electrical and magnetic properties, optical properties, mechanical stability of solids, etc. Each laboratory would have the mandate to consider all materials and environments within the aegis of its subject area.

Establish an "Index of Recyclability"

Our present technology has developed indices for "goodness" in certain applications. These include, for example, "strength/weight" ratios for the aerospace industry.

An "index of recyclability" should be developed which might consider the following:

1. Energy required for recycling
2. Availability of raw materials
3. Pollution associated with recycling
4. Ease of collection
5. Cost for recycling vs that for extraction from the earth

6. Availability in the earth's crust.

Establish an "Index of Necessity" of a Given Material

A material is clearly necessary if the machine cannot perform without it. Uranium, for example, is a clear necessity for nuclear fission. Transistors, magnetic materials, superconductors, etc., are also a special need. However, materials in use are not specially necessary except for historical or transient economic reasons.

Especially for large tonnage application this "Index of Necessity" should be developed especially if the material cannot be reclaimed.

Establish and Promote Key Elements of "Recycling Science and Technology"

Recycling science and technology might involve the following:

1. Development of systems in which various materials can be recycled. This would include power systems, collection system, flow system.

2. Improve dissolution and resregation technology. This would include consideration of a broad variety of environments. Special emphasis would be placed upon fused salts for metals where electrochemical separation and high reaction rates are possible.

3. Study design of systems from the point of view of recyclability. Thus, for large quantities of consumer items, special materials, compositions, designs, etc., would enhance the ease of recycling with respect to consumption of power, and the environmental pollution.

Emphasize Developments in Interfacial Science and Technology and Chemical Stability of Solids

A large fraction of the processes involved in recycling involve the interaction of one phase with another at some kind of interface. Either we wish to make the reaction more efficient, for example a destructive reaction as might be the case for recycling; or we may wish to enhance the stability to prevent deterioration and preserve a material so that the replacement cycle will be lengthened.

This field touches an enormous number of disciplines and sub-disciplines such as: electrochemistry, colloid chemistry, catalysis, optical properties, wear, surface tension, corrosion, lubrication, electroplating, adhesion, coatings, mass transfer and fluid flow, heat transfer, radiating bodies, etc.

Emphasize Developments in Coated Products

Frequently the surface of a metal needs to be only a few Angstroms thick

to perform its function while the bulk of the material needs only to give form and strength. Such surface functions include appearance, corrosion resistance, erosion resistance, optical properties, electrical properties, hardness, etc. Composite systems might optimize the Recyclability and Necessity Indices.

Emphasize Developments in the Understanding of Complex Destructive Processes Involving Chemical-Mechanical Interaction

A great many of the processes by which engineering systems fail involve complex and synergistic interaction between mechanical and environmental processes. These processes include fatigue, wear, erosion, impingement, cavitation, stress corrosion, and machining processes. The latter, machining, may be greatly improved, and hence an economic benefit would result.

The complexity of these mechanical-environmental problems requires substantial effort to understand. Major advances are highly desirable because, as a set, they are the most frequent of the destructive processes of materials.

Encourage the Development and Use of Consumer Systems Requiring Less Energy and Materials

While George Romney used his concept of the "Dinosaur" to sell American Motors, he was still right. We have no right to use automobiles which are at least twice as large as we need for most purposes. Large cars consume more metal, more fuel, and produce more pollution than do small ones. Further, production of small cars would produce less pollution and consume less energy in the fabrication process.

Housing is another example of wasted materials and energy. Building costs need revision. Housing requires too much energy both for heating and cooling. Further, the quantities of material used in housing are too large and essentially non-recyclable. Excessive energy is consumed, then, not only in operating the housing but also in the manufacture of the unit.

Similar considerations apply to other consumer items.

Encourage Use of Low Atomic Number Materials

Materials of low atomic number in general are the most abundant. The table below summarizes significant data. (Table II) Also, the chemical composition of rocks is of interest. (Table III)

These data suggest that primary emphasis should be placed upon materials containing Si, Al, Fe, Ca, Na, Mg, K, and Ti for large volume engineering materials.

Consider Laws Which Permit and Promote Collaborative Research in Important Industries

There are currently major materials problems in the nuclear industry, the automotive industry, the chemical industry, primary metals producers and others which are nominally competitive and which are bound by anti-trust legislation. Major advances are presently being hampered by lack of a collective industrial effort to find solutions.

Other industries such as utilities, are limited for publication and exchange of information because of legal liability for failures. Many European countries as well as Japan are not hampered by such problems.

We need to free industries from such restraints so that we can advance the technical development without reducing desirable competition in the one case as well as assuring public safety responsibility.

Ultimately, the consumer would also benefit. Also our international trade position would be strengthened.

More Efficient Accessibility to All Technical Information Produced in the World

A major resource of the world remains untapped--the accumulation of scientific and technological information. While it is always available to the patient multilingual scientist, these riches are frequently not available to the small company or even the large one for reasons of time, knowledge of existence, unfamiliarity with library systems, or lack of foreign language facility.

Further, there are vast sources of information available as company and government reports which are not a part of the abstracted literature.

Another apparently trivial but frequently important difficulty often arises. The required text is out of print, lost, not available locally, on someone else's shelf, or in the wrong language.

An international technical library should be set up wherein all information becomes immediately available and all sources are tapped. This would include on an international basis:

1. Technical journals
2. Government reports
3. Company reports
4. Newspapers
5. Books
6. Theses and Dissertations

TABLE II
AVERAGE IN EARTH'S CRUST IN PARTS PER MILLION*

Element	Amount	Element	Amount
O	466,000	V	150
Si	277,200	Zn	132
Al	81,300	Ni	80
Fe	50,000	Cu	70
Ca	36,300	W	69
Na	28,300	Li	65
K	25,900	Sn	40
Mg	20,000	Nb	24
Ti	4,400	Co	23
H	1,400	Pb	16
P	1,180	Mu	15
Mn	1,000	Be	6
S	520	Ag	0.1
Zr	220	He	0.003
Cr	200		

* Handbook of Chemistry and Physics, 46th Edition

TABLE III
COMPOSITION OF ROCKS*

Element	Avg Igneous Rock	Avg Shale	Avg Sandstone	Avg Limestone	Avg Sediment
SiO_2	59.14	58.10	78.33	5.19	57.95
TiO_2	1.05	0.65	0.25	0.06	0.57
Al_2O_3	15.34	15.40	4.77	0.81	13.39
Fe_2O_3	3.08	4.02	1.07	0.54	3.47
FeO	3.80	2.45	0.30	-	2.08
MgO	3.49	2.44	1.16	7.89	2.65
CaO	5.08	3.11	5.50	42.57	5.89

*
Handbook of Chemistry and Physics, 46th Edition

Further, all written material would be automatically translated into a single language for inclusion in this international library.

It also would be desirable for the literature to be reviewed periodically by teams of competent scientists-technologists to assess significance, progress, new direction.

Such efforts should be encouraged and funded. This work is just as important as the research itself. Special emphasis should be given to the use of teams in view of the inherent limitations of individuals.

Improve Collective Technical Leadership

We make poor use of our collective technical talents in major national decisions in all aspects of materials policy.

We need to establish ready avenues to finance and promote ideas which focus, evaluate, and plan activities in connection with materials. Such activities should provide leadership in areas as narrow as critical considerations of protective films on iron to areas as broad as recycling policy.

Total Environment Concept for Materials Performance

In the performance of engineering structures consideration is usually given only to the standard and steady state environment in which a system operates. However, failures often occur or originate in other circumstances such as: initial fabrication, shipping, storage, installation, testing, shutdown or repair. It thus becomes necessary to define as well as to control the environmental circumstances of such environments. The extent of such concern depends greatly upon the investment and consequences of failure.

Develop Handbooks with Environmental Modifications of Strength

Present handbooks used by designers of structures have little or practically no reference to the synergistic degradation of the strength of materials by environments. Such inputs are necessary in view of the fact that a large fraction of failures occur for reasons of the mechanical-environment interaction.

Delicate Nature of Materials, Need for Forgivability, The Achilles Heel

Engineering materials are probably a great deal more fragile than the non-materials public would expect. The following environmental-mechanical failures attest to such fragility:

1. Titanium is methyl alcohol
2. Stainless steel in pure water

3. High strength steels in pure water
4. Aluminum alloys in pure water
5. Copper in ammonia
6. Rubber in ozone
7. Glass in water
8. Liquid metal embrittlement at room temperatures.

We need to accustom ourselves to such fragility while at the same time giving ourselves increased forgivability by improved design of materials and environmental control.

We need also to understand the field or "volume" described by the variables which control the onset of this phenomenon so that we may design to avoid such phenomena with a greater confidence.

Also, we frequently are "taken in" by claims of false capacity such as "space age material," "exotic," "high tensile," "superalloy." We would do well to avoid these and similar descriptions.

Reduced Emphasis on Breakthrough in Favor of Solid Developments

Fundamental research on materials has been subject to the "yo-yo phenomenon" depending on the failure of various important components in the National Defense Establishment.

Further, the steady stream of program managers in the various federal agencies has produced a mania for making a quick mark--usually in two or three years. Many of the complex materials questions cannot be understood in such short times. Thus, the same problem is studied for three year periods in a ten year cycle.

Need For a New Breed of Technical Leader

A new type of technical leader is needed in the present circumstances. He needs the technical sophistication of the usual Ph.D. but also he must be a competent generalist. Also he must be acutely conscious of the political-economic world in which research and technology operates. He must also be sensitive to the needs and avenues for translating the nuance of science into practically realizable terms. He needs to be energetic, vital, and articulate, contending now as he must, with lawyers, environmentalists, the general public, and those who control sources of financial support.

These are the ones who will lead science and technology into the "age of concern"--concern for the quality of human development, the resources of unborn generations, the quality of the environment, and the harmonious activity of different peoples on the same globe.

DETERIORATION OF SYNTHETIC PLASTICS AND RECYCLING

by

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ABSTRACT

The deterioration of synthetic plastics is a general phenomenon, resulting eventually in failure of the material. Since only a small fraction of the plastic has deteriorated when many material failures are apparent and the bulk of the plastic remains basically unchanged, recovery of degraded plastics and recycling to less critical applications offers a possible approach to the conservation of synthetic plastics.

INTRODUCTION

With few exceptions, those synthetic plastics which are in commercial use are organic materials. It is therefore to be anticipated that these plastics will eventually deteriorate in the environment to which they are exposed. Deterioration, which may occur either during fabrication or long-term aging, is an irreversible process leading to unacceptable changes in vital properties of the material. It can result from purely physical changes, from chemical reactions, or a combination of these.

There are a limited number of examples in which failure of a synthetic plastic can be attributed to purely physical changes. A notable example would be the environmental stress cracking of polyolefins which occurs when these materials are exposed under stress to liquid media which do not react chemically with the plastic. Examination of a plastic which has failed under these conditions would show no change in chemical composition of the material. In contrast, chemical reactions occur frequently in synthetic plastics, and usually result in an irreversible change in chemical structure.

Chemical deterioration occurs in many ways. Burning of a synthetic plastic represents an extreme case of irreversible chemical change. Thus, polyethylene burns in the presence of oxygen to carbon dioxide and water. In the complete burning of polyethylene, approximately 3 1/2 grams of oxygen reacts with each gram of the plastic. However, mechanical or dielectric failure often occurs when as little as 0.0014 grams of oxygen have reacted per gram of polyethylene. That is, reaction with oxygen at very low levels causes changes in polyethylene sufficient to destroy most useful mechanical and

electrical properties. It is obvious that at this low level of reaction only a very small fraction of the molecules in the bulk of the plastic have reacted. Hence, the potential to recover a large portion of a failed plastic is evident.

Reactions Leading to Deterioration

Polymers fail at relatively low levels of chemical reaction because their inherent strength is directly related to both their molecular weight or molecular weight distribution and to the morphology of the material. Reactions which lead to failure are of three general types. The first of these is chain-scission, which involves lowering of the molecular weight and which may occur either by reversal of the polymerization process with regeneration of the monomer, or by a random process resulting in gradual reduction of the molecular weight. Cross-linking on the other hand is a reaction in which neighboring molecules of the plastic are joined together by chemical bonding. This latter reaction is typified by the conversion of natural to hard rubber through an extension of the vulcanization process. Thus, cross-linking increases molecular weight leading to network structures and, ultimately, to gel formation. Important changes in morphology (physical structure) of the plastic usually result from either chain-scission or cross-linking. In many plastics, chain-scission and cross-linking occur simultaneously. Despite the fact that either reaction, individually or jointly, can result in failure at an early stage in the reaction, the bulk of the polymer is unreacted when failure occurs.

The third type of reaction leading to deterioration involves reactions of the backbone chain of the plastic with no significant alteration in the size of molecules. These reactions are exemplified by formation of polar groups along the backbone chain of plastic molecules usually leading to adverse changes in dielectric properties. In this reaction also, failure can occur at low levels of reaction leaving the bulk of the material essentially unchanged. Hence, synthetic plastic are extremely sensitive to each of the general classes of reaction which lead to deterioration. In most applications, failure occurs after reaction of only a very small fraction of the material. The potential for useful recovery or recycling is thus apparent in all of these reactions.

Factors Responsible for Deterioration

The environment to which synthetic plastics are exposed is quite complex. It consists of many variables, most of which cannot be modified. These components of the environment consist of energy sources on the one hand and chemical reactants on the other. For reaction to occur in the environment, it is obvious that chemical reactants to which a specific plastic is sensitive must be present. It is also evident that the rate at which chemical reactions occur is dependent on the energy absorbed by the plastic.

Energy sources most often encountered in the environment are heat, solar radiation, and mechanical stress. Though chemical reactants are numerous,

those most commonly encountered are oxygen and water. Thus oxidation, or in special instances, reaction of certain plastics with ozone, accounts for the bulk of the failures. Hydrolysis, resulting from atmospheric moisture, is also a common reaction leading to deterioration. In addition, there is a wide variety of other chemical reactants present in the atmosphere in trace amounts which function as catalysts for the primary reactions of deterioration. Oxides of sulfur or nitrogen and organic peroxides are typical catalytic reactants. In the industrial atmosphere or even in the atmospheres of many urban areas both primary and catalytic reactants are common. As has been noted, it is not an easy matter to alter the exposure environment, but it should always be recognized that certain plastics are more resistant to chemical reactants than others. In fact, reactions leading to deterioration are quite specific and dependent on chemical composition of the plastic. It therefore follows that the danger of misapplication is always present. Wherever possible, a plastic should be selected which has an acceptable level of resistance to the environment in which it is to be used.

When it is necessary to expose a plastic to an environment in which it would deteriorate rapidly, considerable extension of its useful life can be attained by the addition of appropriate stabilizers. This is the most common and the most effective approach to delaying the failure of plastic materials.

Stabilization of Plastics

An understanding of the reactions through which a plastic deteriorates and recognition of the variables in the environment responsible for this deterioration are essential in a scientific approach to stabilization. For example, it is generally agreed that thermal oxidation of those plastics, which are basically hydrocarbon in structure, occurs through a free-radical chain reaction. With this background, it has been possible to devise a class of stabilizers which function by interrupting and terminating the chain reaction. There are other steps in the mechanism of thermal oxidation of these plastics at which effective stabilization can be accomplished. In practice, an effective stabilizer can extend the useful life of a plastic by several fold. For example, polyethylene at 100°C fails in approximately 100 hours by oxidative deterioration. Addition of as little as 0.1% of a good stabilizer inhibits deterioration at this test temperature for several thousand hours. Under normal conditions of use, this would correspond to many years of useful life.

Other classes of stabilizers have been designed to protect plastics against solar radiation. These can also be very effective when correctly applied. There is an abundance of chemical literature describing both the reactions of deterioration and the established mechanisms for stabilization. The important point to make is that plastics which would fail rapidly in the environment in which they must be used can, if correctly formulated, maintain their useful properties for very long periods. It is thus important that in the conservation of materials, full advantage be taken of the maximum improvement which can result from proper stabilization.

Recycling of Synthetic Plastics

It has been emphasized that plastics fail when only a very small fraction of the material has undergone chemical reaction or physical change. Thus a synthetic plastic may fail in a given application, and yet, since the bulk of the material is unchanged, it could well be suitable for a less critical application. A useful approach to the conservation of plastics would have as the first step stabilization of the material as effectively as possible before its original use. Then, if the plastic has been designed for an application where very minor changes in properties would result in failure, there is the potential for reclaiming essentially unaltered material and recycling it into an application where the requirements are less rigid. In theory, at least, this practice could be extended several times. The result would be that a plastic could be used in a series of applications with diminishing requirements as deterioration gradually degraded its chemical composition. Ultimately the degraded material might be converted back to its basic elements. For example, deteriorated plastics of miscellaneous origin could be the raw materials for the manufacture of carbon suitable as a filler, e.g., for rubber tires.

TRANSPORTATION AND CONSTRUCTION MATERIALS-

PROBLEMS AND REQUIREMENTS

by

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INTRODUCTION

An effective transportation system has been a major factor in the attainment of this country's economic, social and political position. Mobility is an essential ingredient in the development of any country. Even the Romans recognized the importance of mobility when they constructed the Appian Way, one of the great military roads radiating from Rome. The availability of alternate modes of transportation has made the American the most mobile individual in the world.

In this century, transportation in all its modes has evolved with astounding rapidity.

Less than seventy years ago the Wright Brothers flew the first powered, heavier-than-air machine. Forty-nine years ago the T-2 airplane made the first non-stop flight coast to coast. Now in this decade man has been to the moon and home again. Supersonic jet transports will be a common sight transporting people and goods between nations before the end of this century. In 1929, the first locomotive arrived in America and now, today, rail transportation has an important transportation role in moving people and goods. The automobile entered the American scene during the last decade of the 19th century and has now established itself as the dream transportation of the American public. About eighty percent of U.S. households own an automobile, thirty percent own two or more. At least eighty-six percent of travelers use the automobile in meeting their transportation desires. The importance of motor trucks in transportation is reflected in their increased use as a major mover of commodities.

The overall impact of transportation on the American economy can be inferred by the relationship of energy consumed with the gross national

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product (GNP). Figure 1 shows this relationship. Since business activity generates a need for transportation of people and goods, transportation services fluctuate with the level of the nation's economy. Business and personal use of the automobile account for a major share of the nation's expenditure for transportation. Transportation consumes energy and, as a consequence, is influenced by the energy needs of the country. Transportation exceeds by two times the consumption of household and commercial, industrial, and electric utilities sectors of energy derived from petroleum. In 1970, the transportation of people and goods required about twenty-four percent of the total U.S. fuel energy consumed. The fuel (energy) consumption for transportation more than doubled between 1950 and 1970, as shown in Figure 2. Because of the importance of transportation to the nation's economy and its impact on each individual, materials needed to maintain existing facilities and provide for the desirable growth of new facilities must be made available.

Figure 3 shows the many industry products that are consumed, partially, by the transportation industry. It is noted that seventy-five percent of the rubber products is used in the nation's transportation system. Of the eight products shown, a minimum of nineteen percent is consumed by the industry.

TRANSPORTATION MODES

The growth of the different transportation modes is a prime input in arriving at the present requirements and future needs of construction materials to support the nation's transportation system. The major modes are shown in Figure 4. Highways and the vehicles that use them are the dominate users of construction materials.

The growth of Air Transportation is reflected in the passenger miles of public carriers for inter-city travel. In 1960, air travel accounted for 31.7 billion miles of travel and increased to 104 billion miles in 1970. Of the public carrier modes, air travel is the only one that is carrying an increasing number of passengers in inter-city travel. Bus passengers show a leveling off, while rail is steadily decreasing. Air transportation appears to be in a strong growth pattern through at least year 2000 and probably beyond.

Several states are in the process of developing their 10-year airport system plan. This plan will assist in identifying the needs including airport access, landing aids, terminal construction, and the upgrading of runway facilities to carry the larger aircraft. Existing airfields adequate to carry the 727 aircraft will have to have an increase in pavement thickness of about eleven inches to support the jumbo 747. This, of course, points to a need for additional construction materials.

New developments in air transportation will effect the use of air travel as a mode of inter-city travel. These include the vertical take-off and landing, and the short take-off and landing aircraft.

Air travel may be constrained, however, because of the concern that people have for its impact on the environment. The demise of the SST and halting of the Everglades airport indicate the peoples' concern with noise and air pollution.

Federal legislation that will be important to airport development include the Airport and Airways Development Act of 1970 and the creation of an Airport Trust Fund. These two items of federal legislation will have an impact on future air travel and the need for support facilities.

Railroads, at one time in the nation's history, were a major people mover and goods hauler. Today, the total volume of inter-city passenger and freight traffic has decreased. Even so, in 1970, the railroads hauled some 770 billion ton-miles of freight. In spite of this large volume of commodity movement, the main line mileage of roadbed has steadily decreased since 1929 to a present low of about 209 thousand miles. As a consequence, railroads are a relative small user of construction materials, except in the maintenance of existing right-of-ways.

There are new developments in rail travel that will have an impact on the industry. The design and production of high-speed equipment which will require not only new uses of materials, but expanded uses of existing materials.

The immediate needs of the railroad industry are the improvement of the alignment and grade tolerances on certain lines to support high-speed travel and better suspension systems. Improved rail ballast and crossties are major concerns in the maintenance of a rail system.

Important legislation in recent years has been the 1970 Act that established the National Rail Passenger Corporation for improved services. It is an attempt to revitalize rail travel through improved equipment and service. The Rail Safety Act is also an important piece of legislation that will need to be considered in the establishment of a materials policy.

Water transportation is the country's oldest mode of transportation. It was to the early American an important element in his mobility. The powerboat transportation became a reality to the American public when in 1807 Robert Fulton used steam to power the Claremont, some 150 miles up the Hudson River although, earlier, steamboats were used for river freight traffic. In our early history canal and river transportation was an important travel mode but limited, then as today, by the lack of wide spread water routes.

The movement of bulk commodities on the 25,000 miles of commercial navigable waterways is an important element in meeting total transportation needs. Water transportation on the inland waterways, intercoastal waterways, and Great Lakes coastal harbors account for some ten percent of the nation's commerce. Water transportation is receiving more attention in recent years because of its low cost and new technology such as containerships that reduce dockside time, pilferage, and damage to goods from the weather. Also, the LASH System (lighter aboard ship) lets a Mississippi paper mill compete favorably in foreign markets in Germany.

The greatest construction need involving the use of materials is probably that of constructing access roads to port and harbors and the metals used in the construction of navigation aids and equipment.

Highways are the major transportation mode and they generate the greatest demand on construction materials. This demand is clearly indicated in the knowledge by engineers that pavements are wearing out in seven years rather than the designed twenty years. Approximately 89,000 bridges need to be replaced because of their being substandard and a hazard to the facility that they serve. Highways have a mileage of primary and secondary road system in excess of 650,000 miles that must be maintained to a level satisfactory for their safe and efficient use. It is expected that some 15,000 miles of new roadways may be needed to accommodate the new vehicle concept that are being considered by the U.S. Department of Transportation. Transportation products will pour some 225 billion dollars into the construction economy during this decade. The 1970-1990 total needs in highway transportation alone are estimated at 600 billion dollars.

Beginning in August 1972, the 1974 transportation needs study will get underway and when completed will provide an insight into the present facilities being utilized and the needs for new facilities to support the total transportation system.

CONSTRUCTION MATERIALS

Because the highway system is the major consumer of construction materials, the needs in this area are discussed in greater depth. The five primary types of materials that are an integral part of the transportation industry are shown in Figure 5. These include aggregates, bituminous materials as related to roadway pavements, cement, petroleum products largely related to those needed for the support of the vehicles that use the highway, and metals that are used in the vehicle design as well as certain elements of the roadway such as bridges. Supply and demand for these materials in the highway industry have only been systematically determined on a continuing basis in recent years. Similar information is needed for the other transportation modes if an effective materials policy is to evolve. The Federal Highway Administration, U.S. Department of Transportation periodically reports on the usage of the major highway construction materials as an aid for planning by the industry. The U.S. Bureau of Mines through its mineral industry surveys provides yet another source of data on major construction materials used in and by the transportation industry. Some of these more specific needs are discussed in the following paragraphs.

Aggregates, whether natural or artificial, are a major item in constructing transportation facilities. They constitute between 75 and 100 percent of the construction elements in which they are used. They may account for as much as 15 percent of the total construction costs of a facility such as a bridge, highway, or building.

A major factor in arriving at a materials policy for the aggregate

industry will be that of determining the supply and demand for crushed or broken stone that will occur to the year 2000. Trend projections and forecasts have been published by the U.S. Bureau of Mines as shown in Figure 6. This figure contains the straight line demand trends for both a 20-year and 5-year period. It may be noted that the straight line trend projections fall below the forecast demand range for the year 2000. This is attributed to the fact that the growth for forecast demand is increasing exponentially while the annual growth increment for the straight line trend is constant.

In 1967, the American Association of State Highway Officials and the American Road Builders' Association Joint Cooperative Committee engaged in a study of the materials industry's capacity to adequately supply the continuing highway program. The results of the section of this study regarding aggregates are tabulated in Table I. The study related specifically to the requirements anticipated for the years 1975 and 1985. It may be noted from the Table that a "surge" in consumption of aggregates for highway use is predicted to occur in 1975 with a return to "normal" in 1985. If this need for increased capacity actually comes about, then the industry will probably meet the demand by increased plant capacity or, on the other hand, the demand may be met through a shifting of requirements in other areas of use. For example, the continued decline of crushed stone used as railroad ballast may provide a reserve capacity that could be shifted to meet the demand in other areas.

The Federal Highway Administration reports on highway construction usage factors that can serve the industry in estimating future aggregate requirements for highway construction and maintenance programs. The factors as shown in Table II when multiplied by the millions of dollars for a construction program will yield a reasonable estimate of aggregate requirements. The data used in the development of these usage factors is quantity of aggregates used and reported by contractors upon completion of highway construction projects on the Federal-aid Primary System. The factor is a quotient obtained when total quantities are divided by corresponding totals in millions of dollars of final construction costs. It is reported that aggregates constitute between 21 and 31 percent of the cost of all materials and supplies for a highway project and between 10 to 15 percent of the total construction costs for highway projects exclusive of the costs of right-of-way and engineering.

A sound materials policy that included aggregates must take into account future uses of aggregates that are different or expanded from those of today. An example is the use of limestone in cleaning SO_2 from stack gases. This use, alone, may annually require nearly 100 million tons of limestone. Other areas of use that most likely will have expanded growth and require more limestone are water treatment plants, chemical industry, glass making and home building. In transportation, an increased use is expected particularly in airport construction. The 1972 National Highway Needs report that Secretary Volpe transmitted to Congress contains a backlog of construction needs that will require aggregates. Trend projections and forecasts show that growth in the stone industry is expected to exceed 4 percent annually through the year 2000.

It is generally conceded that reserve deposits of source materials used in the production of crushed stone aggregates are unlimited. These reserve deposits could be virtually eliminated, however, by unwise control regulations and land use zoning at all levels of government. In view of this, the major areas of concern of the aggregate industry most likely are: (1) Land Use Planning; (2) Zoning; (3) Pollution Controls; (4) Depletion; (5) Research and (6) Manpower.

Probably the most important factor relating to the industry meeting demands through the year 2000 is the problem that is being created by urban sprawl. The spread of cities and the accompanying land use and zoning regulations will have a major impact on the stone industry. In many areas, substantial deposits of aggregate that could be quarried or processed as construction aggregate are being built on by subdivisions and shopping centers. The vacant land left in and around these areas is being zoned at such a level as to prohibit commercial aggregate development. There needs to be a land use policy that would recognize the importance of eliminating a natural resource from its desirable planned development.

In a recently completed study into promising replacements for conventional aggregates for highway use, it was concluded that (1) the United States as a whole had an abundant supply of conventional aggregates suitable for highway construction; (2) there are localized areas within the United States that have a serious deficiency of the conventional aggregates; (3) raw materials for use in the manufacture of synthetic aggregates are abundant throughout the country; (4) various beneficiation processes are available to upgrade unsuitable aggregates and waste materials to usable quality; and (5) the technical capability currently exists or can be developed to provide all of the aggregates of suitable quality needed in the future.

The supply is available in most areas of the country, provided the environmental regulations and land use zoning does not become too restrictive.

Bituminous materials used in highway construction are asphalt, road oil, and tar. It is estimated that by 1985, 25 million tons will be needed by the highway industry alone. Total needs may run as high as 44 million tons. Although there was an apparent shortage in 1970, industry reports that it can keep with the demand.

The transportation industry consumes more Petroleum than the three other major consuming sectors, i.e., household and commercial, industrial, and utilities (electricity generation). Petroleum products supplied 43 percent of the total energy consumed in the United States in 1970. Consumption averaged 14.7 million barrels daily. For the past seven years the nation's excess petroleum capacity has declined. By 1985, 12 million barrels per day will have to come from imports or synthetic fuels derived from coal, shale, etc., unless new unanticipated sources are discovered as crude oil has a short life span. In 1970 the "lifetime" for crude oil was projected as ending in the year 2001. In 1971 the depletion date of 2001 was reconfirmed.

Cement, like bituminous materials is combined with aggregates to produce

the end product for transportation. Its primary use in transportation is for bridges and pavements. Of the 687,000 barrels that is projected as a total need by industry for the year 1985, less than one-third will be consumed by the transportation industry. Industry reports that production can be increased by about one-third with the present plants and, therefore, there is no anticipated shortage by the year 2000. A significant constraint on the cement industry, however, may well be the local zoning laws that could "dry up" raw material sources. Also, air-pollution controls may reduce capacity particularly on the older plants.

The most used Metal in the transportation industry is steel. Steel is used in bridges, pavements, guardrails, sign posts and many small hardware items. Steel may account for up to 15 percent of the total construction cost. It is estimated that the highway industry will consume 9 million tons of steel in 1985. The industry capacity is quite adequate to keep up with the highway demand.

There are other materials that are consumed by transportation, including timber and aluminum, however, the most significant of these are those that were discussed.

SUMMARY

There are many factors that will determine the industry's capacity to meet the demands for transportation materials by the year 2000. Several of the more important factors are shown in Figure 7. These include local, state and federal legislation, development of new technology and products, the ability to recycle significant amounts of materials for similar or new uses, the use of existing technology to improve production, and the priorities that are set by the public on the need for transportation services.

Transportation modes will be strongly influenced by legislation. There are and will continue to be constraining factors of varying degrees that must be taken into account in the development of a national materials policy. These constraints may well force a change in the public's preference for transportation mode and as a result may change priorities. A change in public priorities should be reflected in policy decisions.

The conservation of our natural resources while yet supplying the demand for materials and goods, is a broad base problem for the transportation industry. It is not solely a problem of depletion but is one that involves all the constraints imposed by the factors shown in Figure 7. Establishing a national materials policy must be faced from a system viewpoint. In one instance, energy derived from a particular material may be vital to the community whereas the residue in using the material can disrupt another community. The universe is complex even as much as the people that live in it. Future scientific advances and the development of new sources of raw materials and better utilization of existing materials will aid in the production of the required materials to insure a well planned and constructed transportation system to meet the needs of the public. The real challenge to the scientific

community over the next several decades will be that of insuring a viable transportation system. A system that will provide a maximum choice of alternatives not only for the citizens of the country, but for the industry as well. Herein lies our need for a policy directed to transportation construction materials to be certain that we can meet the desired rate of construction.

Will Rogers summed the statement concerning natural resources when he said, "What are we doing to want this good luck more than any other nation? How long is this going to last? Our good fortune can't possibly last any longer than our natural resources."

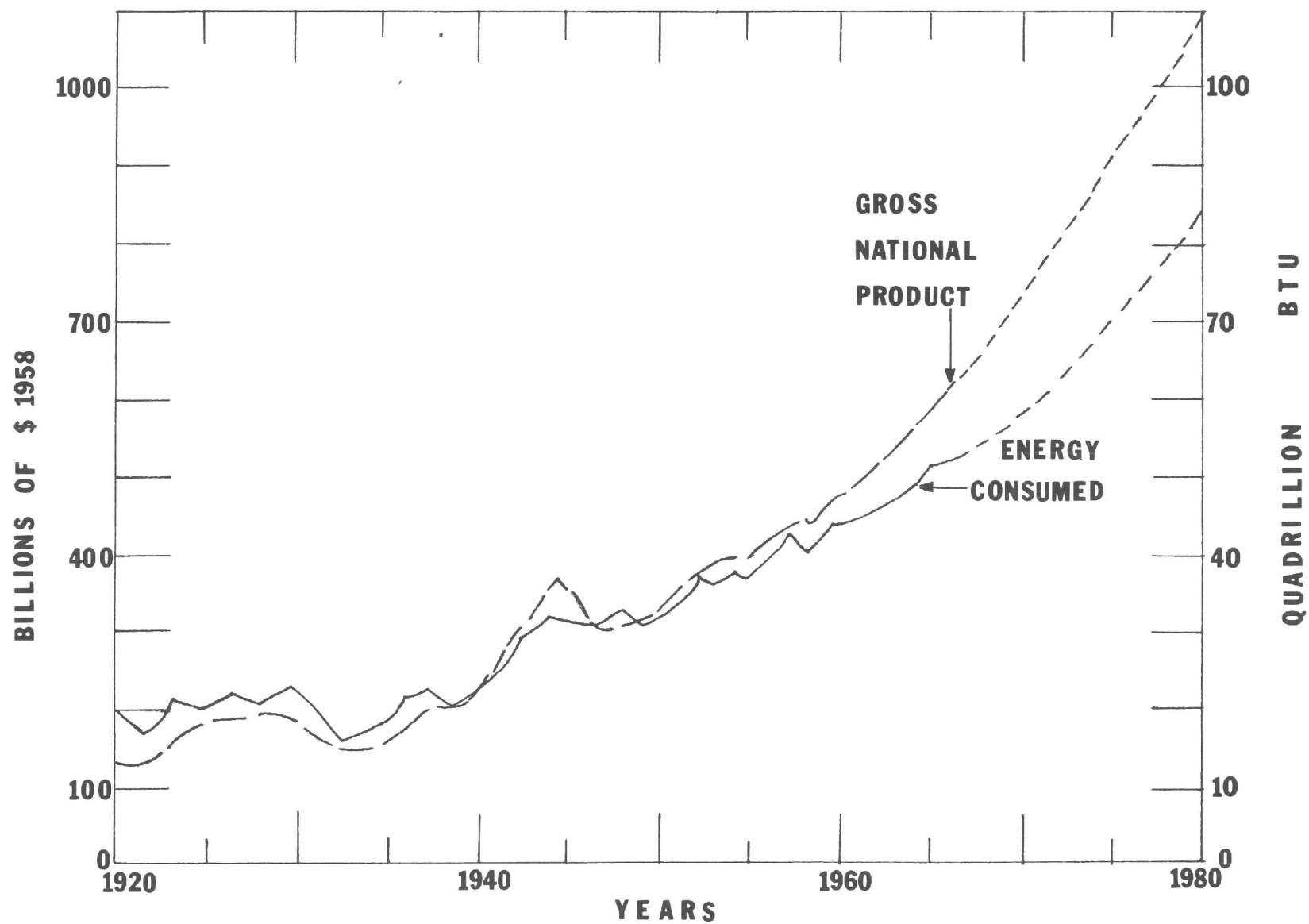


FIGURE 1. Gross National Product and Energy Consumed

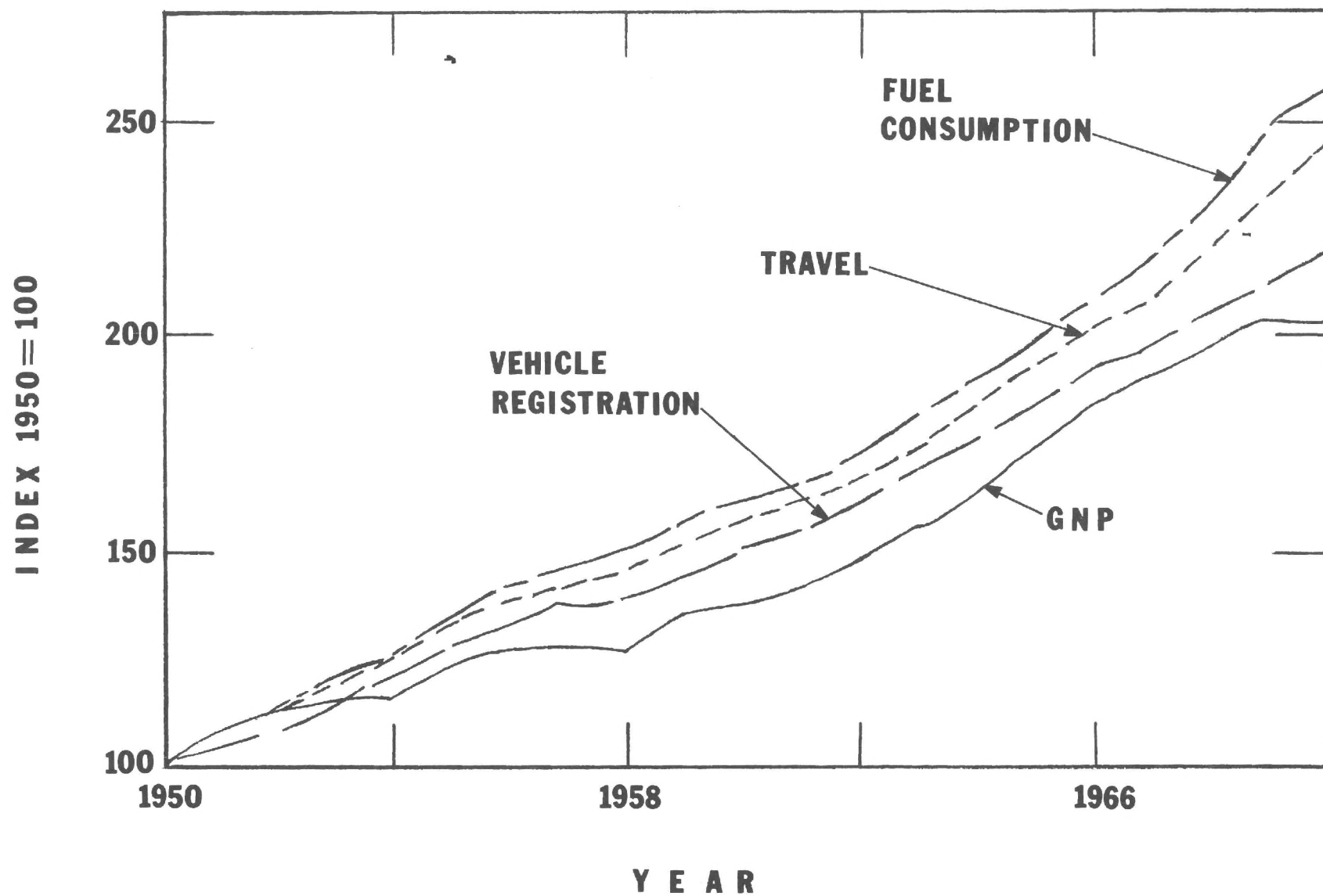


FIGURE 2. Fuel Consumption as Related to Gross National Product.

TRANSPORTATION CONSUMES

- 75% of RUBBER**
- 56% of PETROLEUM**
- 53% of LEAD**
- 35% of ZINC**
- 29% of STEEL**
- 27% of CEMENT**
- 20% of ALUMINUM**
- 19% of COPPER**

FIGURE 3. Products Consumed by Transportation.

TRANSPORTATION MODES

- AIR**
- HIGHWAYS**
- RAIL**
- WATER**

FIGURE 4. Transportation Modes.

CONSTRUCTION MATERIAL

— AGGREGATES

— BITUMENS

— CEMENT

— PETROLEUM

— METALS

FIGURE 5. Major Types of Construction Materials.

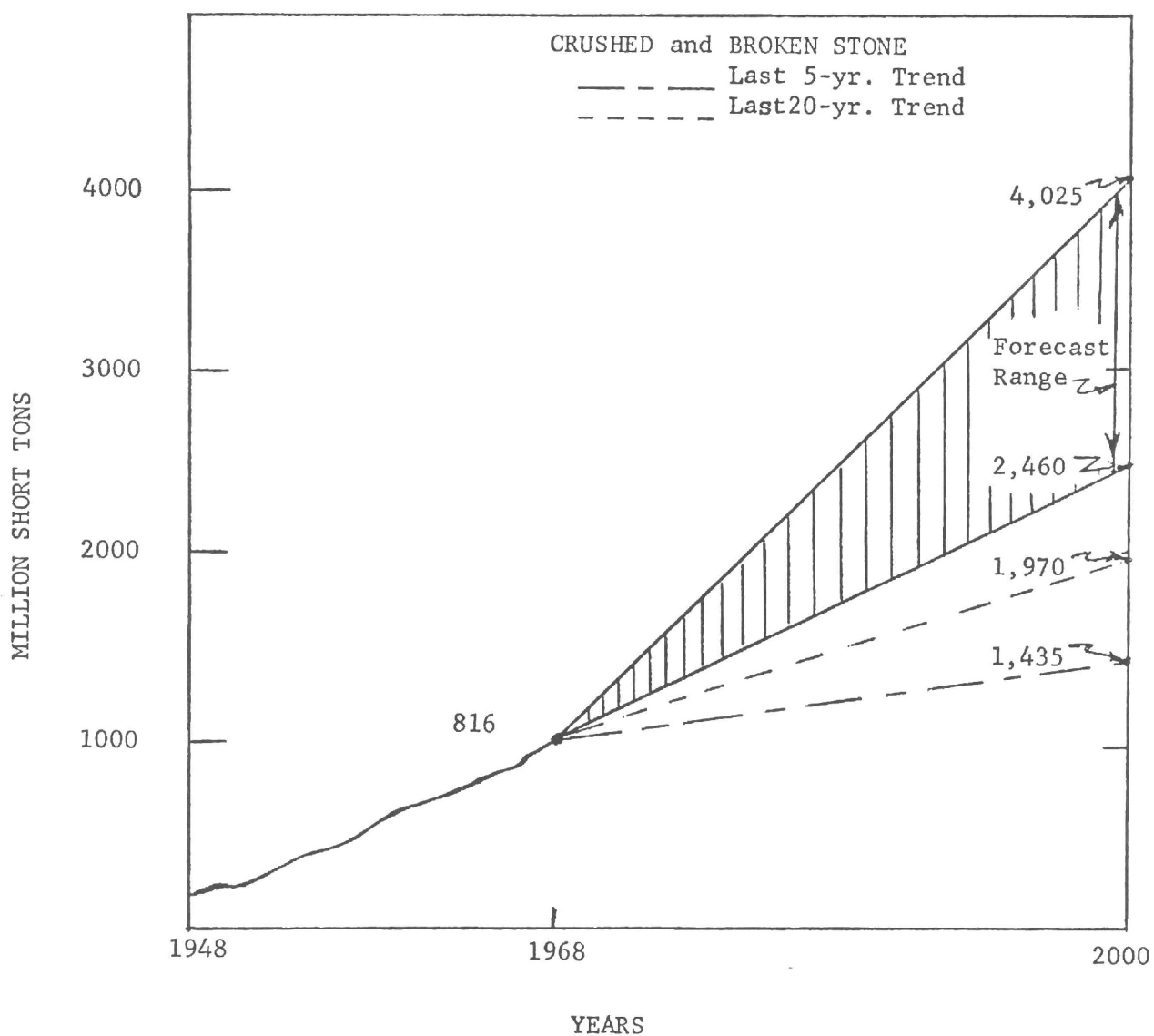


FIGURE 6. Comparison of Trend Projections and Forecasts for Crushed and Broken Stone (U. S. Bureau of Mines).

KEY FACTORS

—LEGISLATION

—ENERGY NEEDS

—NEW TECHNOLOGY

—NEW PRODUCTS

—PRIORITIES

—RECYCLE

FIGURE 7. Key Factors in Arriving at a National Materials Policy.

TABLE I

ANALYSIS OF AGGREGATE INDUSTRY GROWTH

Year	TOTAL PRODUCTION ¹ (MILLIONS OF TONS)				HIGHWAY CONSUMPTION ² (CONSTRUCTION & MAINTENANCE)	
	Sand and Gravel	Crushed Stone	Iron & Steel Slag ^a	Total	Million Tons	Percent-Total Production
1956	625	504	32	1161	443 ^b	38
1961	752	613	27	1392	555	40
1966	934	811	29	1774	660	37
1975	1330	1260	33 ^c	2623	1199	46
1985	1970	2060	37 ^c	4067	1447	36

- NOTES: 1. Total production data through 1966 was obtained from the Minerals Yearbook of the Bureau of Mines, U.S. Department of Interior. Projections for 1975 and 1985 are based on a continued growth rate equal to the average for 1956-1961 and 1961-1966 periods, except as noted.
2. Consumption in highway construction and maintenance through 1966 is based on AASHO surveys and is projected for 1975 and 1985 on the basis of highway needs as reported to Congress by AASHO.
- a. Excludes expanded slag lightweight aggregate used almost exclusively in building construction.
- b. Assumes maintenance added 10 percent to construction use of 403 million tons.
- c. Estimates projected on basis of moderate increase in iron and steel production.

(After ARBA-AASHO Report)

TABLE II

U.S. AVERAGE USAGE FACTORS FOR AGGREGATES

Aggregates	Thousands of Tons Per Million Dollars of Contract Construction Cost			
	Inter- State	Other Primary	Estimated Secondary	Estimated all Highways
<u>1968-69-70</u>				
Purchased by Contractors	39	40	38	39
Produced by Contractors	30	28	62	35
<u>1967-68-69</u>				
Purchased by Contractors	41	48	46	47
Produced by Contractors	29	34	70	39

NONMETALLIC MINERALS OF CONSTRUCTION--A SITUATION REPORT

by

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INTRODUCTION

There is an almost endless number of materials, mineral and other, used in construction. Since my experience has been almost exclusively in non-metallics I am going to discuss only those nonmetallic minerals that are most commonly used in construction at present, or that might become important as construction raw materials of the future.

A number of anomalies can be used to describe certain aspects of the nonmetallic construction materials situation. For example, the greatest supply problems relate to shortages of materials which are in virtually unlimited supply nationally or worldwide. A million tons of a \$2 commodity in New Mexico is of little use for construction in Newark. A mineral may even be plentiful locally, but covered with physical structures, restricted from use by zoning, or otherwise removed from the available category. Here's another: Many environmental constraints result from production of minerals that are relatively inert and are ordinarily nonreactive with the environment. This situation usually occurs in highly populated areas where even a very low degree of environmental damage is often highly objectionable and where noise pollution and aesthetics come heavily into play. Finally, the most important transportation problems often concern those materials that are closest to the points of end use. This is because transportation costs are most critical for the very low cost products and a 20-mile local haul can double the unit cost to the contractor.

Table 1 gives data on 14 mineral commodities, which probably represent well over 99 percent of the volume of nonmetallic minerals of construction. We are self-sufficient in most of them, and potentially self-sufficient in all but one, asbestos, through the end of the century. In most cases where production lags behind demand this is due to economic factors which favor use of imports over the domestic counter-parts. In the case of dimension stone we import special varieties of stone not available in the United States. The 1970 production and demand data were obtained from Bureau of Mines Minerals Yearbook and other published sources. Forecast demand for the year 2000, and domestic reserve data were obtained from Bulletin 650, Mineral Facts and Problems.

Let's take a look at the individual materials now.

Sand and Gravel: Although the total resources of sand and gravel are estimated to be essentially unlimited, this is not true on a local basis and not at presently prevailing prices. Most of the present reserves held by producers will probably be gone long before the end of the century and not enough exists with respect to the known reserves in that most of them are held by producers in areas where supply is already tight. In areas of relatively abundance the producers have not needed to hold large land areas in order to assure future production.

In areas where the aggregate supply has become very tight, extreme solutions have been considered and proposed, including production from off-shore deposits, and long-haul barge transportation from areas of plentiful supply. Long-range advance planning for sequential land use would have protected many strategically located aggregate sources from loss to urban encroachment. The need for adequate planning is becoming increasingly critical.

Quantitatively sand and gravel account for more than half of all non-metallic nonfuel minerals produced in the United States. Construction uses predominate, with only minor quantities going into abrasives, foundry sands, filter media, and other small-volume uses.

Sand and gravel, and the waste products generated in production and processing, are relatively inert and harmless to the environment. Nevertheless, owing to the necessity to produce the material as near as possible to points of use, sand and gravel operators encounter enormous problems related to land use competition and environmental pollution. There are 9,000 producers in the country, and the geographic production patterns are constantly changing through local reserve depletion and from pressures due to environmental factors and competition for urban lands.

Crushed Stone: This is a group of commodities consisting of limestone, igneous rocks, sandstone, and several varieties of miscellaneous stone including shell and marl. About 85 percent of all crushed and broken stone goes directly into construction or is converted to construction materials such as cement and lime. Foreign trade is small, and consists of shipments across common boundaries with Canada and Mexico.

The total value of crushed stone production exceeds the value of any other nonmetallic mineral, and crushed stone is exceeded only by sand and gravel in total quantity of output.

Stone is usually produced as near as possible to the major markets. When the market is a highway construction project in the country, the environmental and land conflict problems are small. When the markets are in urban areas, the pressures build up--fired by the need to locate production near the customers in population centers where environmental and land use problems are on the increase. At some point it may become economical to produce stone from underground, and a few producers have taken the plunge.

Under certain conditions the holes can be converted to storage and other uses when mining is completed and may be more valuable than the stone that was produced from them.

Dimension Stone: Dimension stone production and installation have historically been labor intensive industries which have found it increasingly hard to compete as mass production mining and construction methods have developed. Dimension stone is now used primarily where a dignified and prestigious appearance and durability are more important than rapid, low-cost construction. New production and installation methods have been developed for the dimension stone industries, but these have not been sufficient to maintain growth of dimension stone demand at a level with most other materials of construction.

Environmental problems of the dimension stone industry are not great, consisting largely of planning for disposal of the large volume of quarried stone which is not usable, and for the ultimate fate of depleted or abandoned quarries which could be hazardous to people or livestock in the vicinity. Dust problems involved in quarrying and finishing of siliceous stone also require attention, primarily owing to health hazards such as silicosis.

Clays: Major construction uses for clays are the heavy clay products such as brick and pipe, lightweight aggregates, and portland cement components. Clays for these uses are mostly the impure illitic varieties classified as miscellaneous clay. The demand growth rate for the miscellaneous clays is very low, on the order of two percent, with only one rapidly growing component, lightweight aggregates.

Resources of the miscellaneous clays are virtually unlimited, although clays with particular characteristics, such as desirable fired colors and bloatability, are often difficult to locate on a local basis. Substitutes are available for all structural clay products, and competition between products is great. Labor is a major cost factor working against greater growth of brick demand, and transportation costs are critical in establishing markets for the low-cost building products. In many cases firms can only expand by establishing numerous plants, each centrally located to a separate market.

Environmental problems and land use conflicts arise because of the necessity for placing clay products plants as near as possible to the principal markets they serve.

Clays have been studied for many years by the Bureau of Mines and private industry as a source of aluminum, and technical feasibility has been established. Sometime in the future, perhaps by the mid-1980's, aluminum from clay may become a commercial reality. While this is desirable we need to be studying ways for utilizing or disposing of the large quantities of wastes which will be generated and which could become a major environmental constraint.

Gypsum: While we ponder what to do with 150 million of impure byproducts gypsum obtained from phosphoric acid plants in Florida, with 21 million tons

added each year (and increasing), we import six million tons per year from Canada and Mexico, principally for production of wallboard, plaster, and cement additives. Domestic mine production of gypsum is about 10 million tons annually, or half as great as the annual buildup in Florida.

The domestic resources of gypsum are more than adequate to supply the U. S. demand far beyond the end of the century. Nevertheless, imports will probably continue to be an important component of supply owing to transportation cost advantages to product manufacturers located in coastal cities.

A short time ago it appeared that it might be necessary to utilize gypsum as a source of sulfur. Now, with new sources of primary and by-product sulfur, and the necessity of removing large quantities of sulfur compounds from stack gases to reduce environmental damage, the shoe is on the other foot with a disposal problem of major proportions looming.

Sulfur: Only four years ago the supply of sulfur was low and resources appeared to be inadequate. Extreme measures appeared necessary to assure an adequate quantity of sulfur to support the consuming industries, and one firm made an unwise decision to produce sulfur from gypsum. Today sulfur is plentiful and low in price, and potential for enforced recovery of sulfur compounds from exhaust gases from utilities and manufacturing plants is growing rapidly.

Sulfur is not presently used to an appreciable extent directly in construction or construction products. However, there is a need to find new uses for sulfur and the construction field appears to offer the greatest untapped potential for absorbing the large quantities which could result from the environmental cleanup that is underway. Barring new large-scale uses, disposal of the environmental-related sulfur compounds could present new secondary environmental problems.

It is known that sulfur coating on brick and concrete block can replace mortars in some applications. This potential use as well as others should be investigated.

Feldspar: Although feldspar is one of the most common rock-forming minerals, commercial deposits of the type presently exploited are not as common as might be assumed. With somewhat higher f.o.b. prices than those presently prevailing, granite could become an economic source of feldspar and the resource base would become much more widespread and essentially limitless.

Major construction products containing feldspar as a principal ingredient are flat glass, ceramics, and enameled steel, with glass far in the lead.

We are caught in a terminology trap with respect to feldspar, having given different names to other similar materials--aplite and nepheline syenite--which contain feldspar and are used more or less interchangeably with feldspar. About one-third of the feldspathic materials requirement is supplied by Canadian nepheline syenite, and a substantial but lesser part by

aplite from Virginia. All of these materials might logically be lumped into the feldspar category, with better statistical reporting and long-range forecasting as a result.

Talc-Group Minerals: For many uses, particularly in ceramics and filler applications, the talc-group minerals--talc, soapstone, and pyrophyllite--are competitive with clays, magnesite, alumina, silica, and other mineral raw materials. Present output of crude talc is about one million tons a year, of which over 10 percent is exported. A complete breakdown is not available but it is estimated that over 50 percent of domestic demand goes into construction products such as floor and wall tile, paint, and roofing.

Although the domestic reserves of talc-group minerals are in total more than adequate, the geographic distribution of the known reserves is far from perfect. Resource data are inadequate for the central and northcentral States, and lack of local supply probably inhibits demand in a large part of the United States.

Talc materials from different locations vary greatly in mineralogical and chemical characteristics. They are not interchangeable, and many potential markets are undoubtedly lost to competing materials for which alternate supply sources are available.

Magnesium silicate dust is a health hazard, and dust control is necessary in talc mining and processing operations.

Asbestos: This mineral material has been in the news in recent months owing to health hazards attributed to its production, processing, and use. Both asbestosis and cancer, according to testimony, can be caused by exposure to air concentrations as low as two + 5-micrometer fibers per cubic centimeter in working environments. One application, sprayed insulation, has been prohibited in several cities. Glass fiber, silicones, organics, and plastics are partial substitutes for asbestos in some applications, but none is entirely satisfactory, particularly for the large-volume uses such as asbestos-cement products.

The United States produces only 17 percent of the total domestic requirement, but a slightly greater percentage of construction grades. Canada and the Republic of South Africa are the principal sources of U. S. supply, with Canada supplying the lion's share. Domestic resources, principally in California, are capable of supplying a much larger part of the domestic requirement, but transportation costs from the Canadian deposits favor importation for major markets in the eastern United States.

Mica: Only low-cost, widely available flake mica is used extensively in construction. The principal uses are in wallboard cement, composition roofing, and paints. More than 70 percent of the flake mica is produced as the primary mineral by the producing firms, but substantial by-product flake is obtained from feldspar and clay operations. More than 90 percent of the U. S. output comes from the Southeastern United States and more than 50

percent from North Carolina alone. Resources are widespread throughout the country in pegmatites and mica schists, and the domestic resource base could support anticipated demand indefinitely.

Environmental problems have had no appreciable effect on flake mica output to date because production is from areas generally far removed from major population centers. However, as environmental laws become more prevalent, disposal of waste products generated in mining and milling of flake mica will require more attention by the operators.

New end uses are needed in order to realize the full potential of this easily obtainable, relatively low cost material of construction.

Barite: This mineral commodity is an example of a construction material declining in importance with respect to construction uses. At the same time it is increasing in importance for use in drilling muds and in barium chemicals which have a wide range of end uses. The major construction end uses are in lithopone paints and as an agent for prevention of scum on building brick. The use in paints is decreasing and may be phasing out altogether owing to competition from other pigments, and the use in brickmaking is not expected to experience rapid growth.

Construction uses probably account for only about five percent of the total U. S. demand at present and likely will experience a relative if not an actual decline if new construction-related uses are not forthcoming.

Environmental problems associated with barite mining and processing are not great. Land reclamation costs for one producer in Georgia are extremely high since he is engaged in open pit mining within city limits near a major highway; however, the strategic location also ensures that the land has a high value when reclaimed.

Pumice: All domestic production of pumice, a vesicular volcanic silicate rock, is from the western States. It has relatively high strength, high porosity, and low bulk density. When pumice is used as road surfacing and railroad ballast material, its high porosity promotes drainage and offers skid resistance. As concrete aggregate, pumice competes locally with crushed stone and gravel, and with expanded shale, clay, and slag. The f.o.b. price of construction-grade pumice is low, ranging from \$0.90 per ton for railroad ballast, to about \$2.00 for concrete aggregates. The average price in 1970 was \$1.50 per ton. This compares with about \$1.20 per ton for sand and gravel and \$1.58 for all crushed stone. On a volume basis it appears that pumice is cheaper than the other natural aggregates.

Most of the domestically produced pumice is used in the West where it is mined. A small quantity of pumice is imported into eastern States from Italy and Greece.

Environmental and land conflict problems have not significantly affected production because most of the producers are located at considerable distance

from population centers. Dust is generated in crushing and grinding operations, and disposal of large quantities of unwanted fines at some operations may become an increasingly important environmental consideration.

Perlite: Use of perlite in construction is relatively small, on the order of 300,000 tons per year. It is a useful material of construction after expansion by heating into a very light product, weighing from 3 to 12 pounds per cubic foot. Its principal advantages are low bulk density and good heat insulating and acoustical characteristics. Construction products incorporating perlite include insulating wallboard, plasters, and acoustical tile. Use of the lightweight material often results in savings in structural steel and foundation work.

Environmental problems associated with perlite mining are not severe because the production is mostly from remote areas and the total land disturbance is small. Dust control is necessary in processing plants, and disposal of waste fines, which account for about 25 percent of the feed material, is a problem.

Imports are nonexistent at present but could become a factor as eastern markets grow. Potential for exports does not appear great. No new large-volume uses are known to be in the offing, but the U. S. reserves of several hundred million tons are adequate to support output at several times the forecast rate well beyond the year 2000.

Vermiculite: This mineral resembles mica in appearance but expands into a lightweight product when heated rapidly, usually in the temperature range from 1600° to 2000°F. Demand in the United States averages about 300,000 tons per year, and construction uses probably account for about 80 percent of the total. Concrete and plaster aggregates and thermal insulation are the major construction uses. Since the aggregate is of low strength, it is used only in non-load-bearing applications where weight saving and/or thermal insulation is important. The excellent acoustical properties imparted by vermiculite are also important in many applications.

Competing mineral raw materials are pumice, perlite, and expanded clay, shale, and slag. Although resources are fairly widespread, production in the United States comes mostly from Montana and South Carolina, with small amounts from Texas and Arizona. The United States and the Republic of South Africa in that order are the leading producers, accounting for 97 percent of known production. Most of the African material is exported to European countries.

The greatest potential for increased use of perlite and vermiculite in construction appears to be in lightweight modular building units for prefabricated buildings. All of the desirable properties--low bulk density, thermal insulation, and sound insulation--are important in these products.

Recycled Waste Materials: There is a large, largely untapped, and growing source of nonmetallic construction materials in the municipal wastes

which continue to accumulate and which must be disposed of in some way. Large quantities of glass, ceramics, ash, and other mineral-containing materials are there for the taking. Fly ash generated by utilities, and mining and mineral processing wastes, add to the store of potentially usable materials of construction. Much research has been done by and for the Bureau of Mines and other Interior Department agencies to determine the technologic and economic feasibility of using the wastes in such construction products as brick and tile, glass wool insulation, and asphalt for roads. A large number of reports have been released on this work.

Conclusions: Some of the problems pertaining to the nonmetallic minerals of construction are going to require major efforts: In order to attain a reasonable balance between mineral sources and other competing land uses in urban areas; in order to reduce the environmental degradation associated with large-scale mineral production to tolerable levels--again particularly in urban areas; and in order to improve the geographic availability of some construction minerals with respect to present and potential markets.

From the review of the individual commodities it is apparent that although there are problems, many of them important and needing attention, by making the necessary efforts we can have sufficient domestic resources of all but one or two of the basic nonmetallic construction materials to meet demand far into the future.

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Commodity	Units	1970		Constant Ratio A/B	Year 2000 Forecast Range		1968 2000 Cumulative		Estimated Domestic Reserves 1968
		A U.S. Primary Production	B U.S. Primary Demand		Primary High Quantity	Demand Low Quantity	Primary High Quantity	Demand Low Quantity	
Barium	TST	478	787	.607	1,600	810	36,000	25,300	33,600
Sulfur	TLT	9,549	9,132	1.046	37,000	23,000	624,000	473,000	2,000,000
Asbestos	TST	125	734	.170	1,865	1,282	40,200	32,700	32,000
Clays	TST	54,853	52,840	1.038	203,500	136,500	3,614,500	2,813,500	Unlimited
Feldspar	TLT	648	578	1.121	3,250	2,070	50,600	32,800	500,000 <u>1/</u>
Gypsum	TST	9,436	14,334	.658	48,000	32,000	895,400	719,800	20,000,000
Mica - scrap and flake	TST	119	119	1.000	547	281	8,850	6,000	120,000 <u>1/</u>
Perlite	TST	456	440	1.036	1,680	900	28,150	19,740	800,000
Pumice	TST	3,132	3,497	.896	19,100	12,100	296,000	222,000	1,000,000
Sand and Gravel	MST	944	944	1.000	3,990	3,153	65,000	56,800	66,000 <u>1/</u>
Stone - Crushed	MST	875	875	1.000	4,025	2,460	61,000	47,000	16,000 <u>2/</u>
Stone - Dimension	TST	1,565	1,740	.899	5,490	4,070	113,000	96,000	50,000 <u>2/</u>
Talc	TST	1,028	948	1.084	3,364	2,284	58,100	46,500	200,000
Vermiculite	TST	285	221	1.290	1,040	540	18,000	12,400	300,000

1/ Resources essentially unlimited at prices above present levels.

2/ Estimated reserves held by producers. Additional resources essentially unlimited.

Sources: Bureau of Mines Minerals Yearbook; Commodity Data Summaries; and Bulletin
650 Mineral Facts and Problems 1970 Edition.

Table 1. - Production Demand and Resource Data for Nonmetallic Minerals of Construction.

TEXTILES USA IN THE EIGHTIES

by

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This keynote presentation on "Synthetic and Natural Textiles" for the regional forum of the National Commission on Materials Policy is an attempt to look at textiles as they are and will be. Textiles and textile industries are so much part of us and have always been with us so that we take them for granted and assume that we are aware or know all about textiles. I believe that we know relatively little about textiles and appreciate even less the impact and importance of textiles in the lives of each of us. Let us stand aside and look at textiles as materials, as a complex of industries, and how textiles affect us. In doing this we consider the following subjects:

1. A look back for perspective
2. What and where textiles are today
3. Needs and requirements of and for textiles
4. Needs in research, engineering, and technology
5. Needs for man and woman power
6. Education
7. Legal, social, environmental, and medical implications
8. National goals for textiles
9. A policy and program for textiles.

This discussion is presented with the firm conviction that we will have in the U. S. in the 1980's a vigorous, dynamic, innovative industrial complex producing textiles and textile related materials, products, and equipment in the U.S. for domestic consumption and for export. We cannot and will not let textiles go overseas. In order to maintain a strong textile industry and other textile based industries in the U. S., we must take this as a national goal and develop a policy and programs for textiles which will nurture textile industries and arts.

A Look Back for Perspective

Textile products and the textile industry have been with us for so long and they are so all-pervasive that we take textiles for granted. A moment's reflection is well worth while.

Wool, linen, hemp, and cotton fabrics predate written history. In the

late stone age, the lake dwellers of Switzerland used hand looms similar to the simpler hand looms so popular among hand weaving hobbyists of today. The new, natural fiber, silk, was introduced about 4700 years ago. Not until our time, or our fathers' times, was another fiber introduced. With the advent of man-made synthetic fibers, in real, commercial effect since 1950, we have seen the greatest change in textiles since cotton came into use five or six thousand years ago.

The story of industrialization is the story of textiles. The textile industry is the first modern industry. Let us consider just a few dates (Table I). The industrial revolution, modern manufacturing, and the factory system began in 1771 when Richard Arkwright built the first factory, a horse-powered cotton spinning mill near Nottingham. By about 1800, much of the textile industry was mechanized and powered by steam engines or water. In 1801, Joseph Marie Jacquard demonstrated the punched card controlled loom which bears his name. This is the first automated machine, the forerunner of our punched card input devices so common in the computer age 150 years later. By 1820 or 1830, Jacquard looms and simpler automatic looms were in wide spread use; mechanization and automation of the textile industry was an accomplished fact. Other industries did not reach comparable levels of sophistication for another century.

The history of chemistry, particularly applied, industrial chemistry, is the history of textiles. Chemistry was textile chemistry for decades. William Perkins' discovery of mauve dye in 1854 triggered the development of industrial, synthetic chemistry. The search for dyes required study of coal tars which led to dyes, drugs, and the myriad of compounds we know today. These compounds include the synthetic polymers which account for over half of our chemical production today. These polymers make our plastics, rubbers, and fibers. Thus, we come full circle in chemistry, from textiles to textiles and Wallace Carothers unsuccessful polyester, his more successful first synthetic rubber, and his spectacular nylon 66. To a far larger fraction than we recognize or admit, our chemical industry is a part of our textile industry.

What and Where Textiles Are Today

With this brief look back, we can see that poor old, "poor mouthing" textiles is not the backward, sickly stepchild of American industry (Table II). Rather the textile industry is an advanced modern complex of industries, a textile-fiber-polymer-chemical-equipment-engineering complex. If the communications industry had the number of firsts in technology and were it as highly developed and diverse as is textiles or agriculture, we would really hear about it. Textiles and agriculture need articulate spokesmen.

We have problems, but we have some strengths going for us. Let's look at them.

First, textiles are man's second most important basic need; only his need for food is more critical than his need for fiber. As long as we live

in a world of nation states, survival requires that we maintain in this country a textile industry capable of supplying our nation's needs at maximum effort. We can no more permit our textile industry to go overseas than we can let go our food, shelter, and health industries.

Our textile industry employs about one million people (1). If we add in apparel makers and those who produce our cotton, wool, and man-made fibers and out textile machinery, the number is 3.4 million (2).

This industry is concentrating in the Southeast. Atlanta is here because of it. For example, textiles and apparel account for about 43 percent of all manufacturing employment in Georgia and North Carolina and about 57 percent in South Carolina. Much or most of this industry is in small towns or rural areas, where we need opportunity for our people, young and older, to stem the migration to the cities and compounding of urban problems. This is rural and small town development at its best; such development must continue.

A special word about the apparel industry is needed. This portion of the textile industry was the major industrial employer in three states in 1967, second in five and third in seven (3) (Table III). Most employees in apparel making are women located in small towns (except in New York which has need for employment opportunities). The apparel industry, a 23 billion dollar industry in 1971 which employed seven percent of all industrial workers in 1967, is particularly vulnerable to competition from overseas.

The textile part of the industry, a 24 billion dollar portion in 1971, has been going synthetic. Total fiber consumption in U.S. textile mills has increased on the average by about 5.7 percent over the past nine years; consumption of man-made fibers has risen by 10.7 percent per year. Cotton consumption increased into 1967 and has decreased since 1966 by 3.5 percent per year. Wool consumption by U.S. mills has fallen precipitously, by 8.7 percent per year for the past nine years (4) (Figures 1,2). This reflects the buying public's turn, with considerable encouragement from fiber and textile producers to synthetic fibers. These trends also reflect our apparent inability to compete with overseas suppliers of cotton and wool fabrics. Hopeful trends observed in late 1971 are levelling out or small upturns in the use of cotton and wool in the U.S.

Knits are doing well up 9.6 percent per year over the past 3 1/2 years (through the third quarter of 1971), but the short term trend was down in late 1971 (4) (Figure 3). We may be approaching the limit of the knits for everything. I doubt that our fiber producers and knitters will convince the American males that knitted, synthetic fibers feel good to nearly the extent that they have convinced our women that nylon tricot is comfortable.

Carpets are the success story, 11.0 percent per year growth over the past three and a half years; all of this growth is in tufted carpet (4) (Figure 4). In Georgia, we're thankful for Elizabeth Evans and her developing tufted bedspreads into the cottage industry from which the Dalton complex grew. We continuously seek those new developments and adaptations, like Whitney's ginning mechanism and tufting; we will need comparable developments with increasing frequency in years to come.

Our biggest problem is that we have priced ourselves out of the world market, not only in textiles but in automobiles, consumer electronics products, instruments, steel, and many other items. Since this is the season for our quadrennial abdication from reason, nothing probably will be done about our ghastly deficit of patents until November eighth--that is if our kindly and generous Japanese, German and Swiss creditors and bankers will permit us to continue in our fairy land of politically expedient inflation. They are realists if we are not; we may have to face up before the day after election to the inexorable working of the conservation principles in economics.

The U. S. has had an increasing deficit of payments in textiles for 13 years now (4). It was an onerous little problem until 1967; now it's become a catastrophe not only for textiles but for the nation. At the end of 1971, the U. S. deficit of payments in textiles was about 2.3 billion dollars per year or about one-sixth of our total deficit (Figure 5). Both the deficit in textiles and the total are increasing precipitously--that in textiles by at least 19 percent per year.

The frightening increase in textile imports is in apparel made of man-made fibers (4) (Figure 6). Because of voluntary agreements with a few nations to limit imports of cotton goods and total yardage of goods, importers have shifted to higher cost, man-made fiber garments. In 1968, for example, about three-quarters of our textile deficit of payments was in apparel (3). This trend has continued with higher priced, finished garments such as suits and dresses made of man-made fibers, making up an ever larger fraction of the textiles imported. Our apparel industry needs help.

Needs and Requirements of and for Textiles

How much we need in textiles in the 1980's depends upon our economic growth. Laurence Christiansen, Editor-in-Chief of Textile World, has written, guessing can be fun (5). So let's use some of his figures which are conservative when compared to others' estimates. Mr. Christiansen expects a 69 percent increase in the gross national product and a 56 percent increase in textiles between 1971 and 1982 (Table IV). These require growth rates of 4.9 and 4.1 percent per annum respectively. Thus, by these estimates, to maintain our relative positions, to stand still, we should double our production and consumption of textiles in 17 years.

These optimistic estimates suppose that we carry on pretty much as we have in the past and that there will be no limitations on growth. Limitations on energy and raw materials are not foreseen nor is the cost of preserving the environment. No allowance is made for drastic "belt tightening" to stop our inflation and reverse our deficit in payments. All of these limitations in the form of higher cost probably will begin to slow down growth in the near future, by 1975 at the latest (Table V). Speaking only as a citizen, voter, and tax payer, without much knowledge and certainly not as an expert in political economics, I expect drastic control of imports and severe curtailment of government spending immediately after this year's election, perhaps, coupled with a tax increase.

We can make the predictions given above by 1982, but only at considerable real cost. We must put our fiscal house in order damping the inflation that sharpens the deficit of payments problem. We must decrease our real costs to become competitive. This will require considerable sums for applied research and development work and for capital investment in plant.

Let us turn our attention to technical needs. All of us have heard that the future is in the fibers we have and learning how to use them--that the last thing we need is a new fiber. I believe that this is patently false. First, I believe that we have experienced most of our future in texturing nylon and polyester to create new fiber and fabric properties. Our efforts have been intense in this rather narrow area. Second, I think that we are nearing the end of the easier developments in the first generation of man-made fibers, single component fibers whose strengths and elasticities are developed by mechanical drawing or stretching.

We must have new fibers, if for no other reason to begin to pass our self-imposed flammability standards. If we don't make these new fibers our textile colleagues in Japan, German, and several other countries will make them and sell them to us, increasing further our deficit in payments.

We need a second generation of man-made fibers. I think that these will be true composite fibers formed by reacting the constituent monomers and low polymers in place in oriented structures. Nature does this quite effectively to make fibers that have combinations of necessary but otherwise exclusive or almost exclusive properties. For example, to combine high strength, pleasant feel to the skin, and non-flammability would require at least two components in a composite fiber reacted or cured after forming the fiber and orienting polymer molecules in the fiber.

Among the new fibers we need and should seek is a cotton-like fiber that won't burn. This non-flammable fiber must feel good, like cotton in well washed flannel or a comfortable shirt. Stronger and tougher fibers are needed for apparel, home furnishings, industrial, and structural uses. I'm certain that our knitters would like to have 20 grams per denier tenacity at break--so would our women who seem to like sheerness in some apparel (Table VI). A real "Man in the White Suit" fiber, indestructible during its lifetime but programmed to degrade quickly to non-toxic, non-polluting products, may well be almost a necessity soon.

Most of the world uses cotton as its number one fiber; most of the organic polymer on earth is cellulose. The big volume, low priced world market probably will continue to be in cotton and rayon. As population and expectations increase in the densely populated regions of the world, the prices of cotton and rayon are likely to rise as has the price of cotton here in the U.S. this last year. We should look to exporting both cotton and rayon, perhaps modified chemically. We should develop new, inexpensive, cotton-like, man-made fibers for export, these probably need not be non-flammable.

Under new fibers and new fabrics, a new, man-made wool with all of the

good feel of real, fine wool and the durability and easy care of polyester knits should find a good market in the more affluent nations. Similarly, very inexpensive cotton-like structures, perhaps non-woven, should be salable in Asia, Indonesia, and South and Central America.

Dramatic increase in domestic consumption has and will be experienced where fibers and textiles are used not for decoration, but as structural materials. The glass fiber-polyester composite is an example. We must develop new high strength, high modulus of elasticity fibers, easier to prepare and less costly than graphite fibers and the high performance nylons and less vulnerable to chemical attack by bases than are glass fibers.

Non-wovens and disposables have grown spectacularly in recent years. Growth probably will continue at a slower pace. Problems of disposal, greater strengths at throw-away prices, and diversity in style, color, size, and shape of formed garments must be circumvented. Another major problem is finding alternate schemes of fabric formation, particularly for paper type, wet processes.

Research, Engineering, and Technology

In the textile complex, we need good, applied research, not on the few months to pay-off time scale of present-day, market-dictated development, but on a few years to return of investment. Well-defined, accomplishable goals should be determined for each research effort. Goals in the form of specific products, processes, and equipment, not time to pay-off or method of study, differentiates applied research from basic research which is directed toward establishing or testing principles or postulates in science. The applied research needed for textiles requires sound, basic scientific endeavor of the highest order coupled with the empiricist's and artist's feel for what will work. This poses exciting challenges for scientists and engineers in the broad field of textiles.

One of the exciting, pressing problems in textiles research is the making of what are truly composite fibers of combinations of new polymers and new structures (Table VIII). For this we must learn the art and methods of oriented, in situ polymerization, the precipitation of oriented polymers in fields and in response to various stresses, and coupling telomers and low polymers in specific orders and orientations. Combustion and flammability as well as controlling degradation to proceed rapidly to innocuous products only when triggered should receive immediate and intensive attention. The plasticizing of polymers and fibers as well as triboelectric behavior merit careful investigation. Of course, the need for new, more varied, and better performing dyes and finishes continues. In purely textile oriented research, studies of new, simple, and fast methods for yarn and fabric formation, by weaving, by knitting, and particularly, by other methods, should be carried on continuously and vigorously in a number of laboratories.

In engineering in textiles, perhaps the most pressing need in the U. S.

is in development and design of new, superior textiles and fiber machinery and equipment, both for production and testing (Table IX). In recent years we have abdicated our position in the machinery and equipment field to the Germans, Swiss, Japanese, Czechs, Italians, and others. We can and must regain most of our domestic market and some of the overseas market for our textile and fiber machinery. This will require efforts in mechanics and machine development and design as well as in controls and automation.

Specific areas of attention for immediate and continuing effort in reducing costs are in yarn and fabric formation. One interesting and needed specific case is the automation of fabric design and weaving so that we can produce as little as 100 yards of fabric at a profit rather than the 1000 to 2000 yards now needed to break even. Our need for long runs because of high labor costs has forced domestic users of high quality fabrics (for apparel, furnishings, and other uses) to seek sources overseas. High quality fabric making has become a lost art in the U. S. I believe that our mass produced textiles are not as good as they can and should be because we do not have the high quality textile trade to set the standards of design and quality to be sought by mass producers.

In the engineering mechanics of fiber and textile systems, mechanical design criteria and formulae for yarns and fabrics, mechanics of fibrous structures, design of structural systems using fibers, and mechanics of fibers as composites and as components in composites need intensive study. Large increase in use of fibers and textiles occur when textiles are used not only for decoration and insulation but as load-bearing members in construction. Engineering design to circumvent fibers' weakness in flexure to use their very high strengths in tension should result in low cost, light, strong, wind and weather resistant structures. The need here is great if we are to house adequately the less affluent members of our society.

The effects of design and structure on flammability of fabrics should receive more attention than in the past. This need is immediate.

Environmental problems in textiles, noise and dust control, air and water pollution and purification, and waste disposal will become more acute in the future. In weaving, one method of minimizing harmful effects of dust and noise is to remove humans from the weave rooms by making operations completely automatic; the same is true for yarn formation. Concern of engineers for these problems will increase sharply this year and in years to come if for no other reason than to comply with the Occupational Safety and Health Act of 1970.

In technical-management areas in the textile complex, methods for controlling the flow of goods, materials, and capital and the work of humans and machines should be refined (Table X). Further, marketing methods to detect and anticipate demands and needs and to generate demand should be improved. The only real advantage of the domestic producer with his high labor costs compared to his overseas competitor is the advantage of time in being close to his buyer. In order to maximize this time advantage the U.S. textile makers must have the fastest, most reliable marketing and control staffs and techniques that can be developed.

Needs for Man and Woman Power

In years to come we probably will need about as many people in the textile industrial complex as are employed now (Table XI). The level of training and expertise will become higher. Women will continue to make up a large fraction of the work force because of continued and increasing requirements for finger dexterity and accuracy, particularly in apparel making, synthetic fiber spinning, and instrumentation. The numbers of semi-skilled workers, weavers, spinners, doffers, etc., will continue to decline while the number of office workers in sales, management, etc., will increase slowly. The numbers trained in textile technology and management probably will increase some at the expense of those without technical training in textiles. The number of textile chemists and textile engineers will increase some as more become available; we have been and are supply limited in "hard science" and engineering in textiles.

To make textiles pay we must have innovative, hard working, dedicated people who move fast from sensing a demand and getting the order to delivering finished goods. This sensing the market and speeding the delivery is what has made and will continue to make money in the competitive market in the U. S.

In research and development, engineering, and positions of advising and control in local, state, and federal governments, we must have engineers and scientists with training, knowledge, and judgment sufficient to make reasonable decisions and to define practical goals. (Recent history of development of flammability standards attests to the need for knowledgeable people.) The number of bachelor's, master's, and PhD degree level people in textile science and engineering and textile chemistry continues to be smaller than the number needed and sought. The textile industry has made up the deficit in engineers and scientists trained in textiles and fibers with immigrants from other disciplines and other countries. This immigration of technical people in textiles will continue. Excellent opportunities are open to native Americans in textile chemistry and textile engineering.

The most vulnerable of textile employees to competition from imports are apparel workers of whom about 80 percent are women and the semi-skilled textile workers. Of course, if production in the U. S. declines or lags other economic growth, other textile employment in management, engineering, sales, R & D, etc., will lag. Particularly vulnerable to imported R & D are M.S. and Ph.D. degree scientists and engineers. A few U.S. based corporations carry on much of their research in Europe or Japan at the present time; for this to become common practice in the textile or any other industry would signal the demise of the industry in the U.S.

Education

People trained in and for textiles and the textile industrial complex are in demand. Consider first the textile chemist who must have fundamental

and practical working knowledge of colloid, organic, polymer and physical chemistry as well as chemical process equipment, textiles and textile processing, and some engineering. With these requirements plus some practical biochemistry, the textile chemist is versatile, useful, needed, and in demand.

Textile engineers are in part mechanical and chemical engineers with detailed knowledge of textiles, textile processes and equipment, and the mechanics of fibrous structures and equipment. Textile engineers make the plants run. Textile engineers with training in electromechanical servomechanisms and switching systems are needed to build and operate the fully automatic textile plants which we must build.

To supply these "hard science" and engineering types trained in polymers, fibers, and textiles the School of Textile Engineering at Georgia Tech offers programs of study and research at B.S., M.S. and Ph.D. levels in textile, fiber, and polymer science and engineering including textile chemistry (Table XIII).

"Hard science" and engineering are not the only routes to technical and technical management in textiles. Our textile majors are trained as vigorously in textiles as are the textile engineers. The textile majors receive some training in management, but take fewer courses in math, science, and engineering than the engineers. These B.S. in textiles grads are employed in technical sales, supervision in textile manufacturing, as industrial engineers, in quality control, and in other technical positions. In relatively short periods many of these people become managers and become responsible in other ways for keeping complex textile operations running.

Among other college trained people, able controllers and market analysts are much needed. As yet, these essential specialists are trained on the job with considerable self teaching.

As the level of sophistication in textile making increases and the training required of operators increases, an ever larger fraction of those employed have some schooling past high school. Well trained textile technologists in two and four year courses are needed. Some of these people should have skills formerly obtained only in lengthy apprenticeships, examples are weaving design, particularly for Jacquard looms, and knitting design.

A substantial fraction of all textile employees need additional schooling from time to time. This instruction is at all levels, from high school to Ph.D., and covers a diversity of subjects from loom fixing to the state of the art in advanced science and engineering. This short course training takes a variety of forms under auspices of different groups, colleges and universities, manufacturers' associations, by corporations "in house," etc. Short course attendance and support is increasing in 1972 after passing through a low in 1970 and 1971.

Legal, Social, Environmental, and Medical Constraints

Legal constraints upon the textile industry are increasing in number and impractical severity at an alarming rate in recent years. The chief impetus is consumer protection (Table XIV).

For example, flammability standards for sleepwear for those under six years are illogical in my opinion. Cotton, from which the most pleasant feeling flannel and other fabrics suitable for sleepwear are made, is a polyglucoside containing hydrogen, oxygen, and carbon, the last in an intermediate oxidation state. Such compounds are extremely flammable; cellulose dust in air is an explosive. Yet, in spite of this obvious inherent flammability of cellulose, so called "reasonable standards" calling for non-flammability have been established. In the face of such blatant disregard of chemical principles, two choices are open: (1) cease to use cotton or (2) use the cotton as a carrier for a heavy add-on of flame retardant. The latter choice requires so much flame retardant that we lose the desirable properties of cotton. Nor is the situation better with polyester or much better with nylon. Even Nomex^R garments will fail the test for sleepwear. The real choices remaining are to use glass, or perhaps saran or vinyon fibers, none of which are comfortable, to make no sleep wear, or possibly to use a Japanese-made co-polymer of poly(vinyl chloride) and poly(vinyl alcohol) that feels not quite awful and might just pass the standard. The last choice exports our sleepwear manufacturing by act of Congress and illogical "reasonable standards."

Another apparent retreat from logic is that in complying with requirements for labelling garments with instructions for proper care manufacturers may be liable for performance of the garment throughout the lifetime of the garment. This liability would exist in spite of manufacturers having no control over the misuse and miscare which the garments receive.

On the plus side in groping toward reason, fewer supposedly responsible officials now call for zero pollution than did a few months ago. Apparently, our colleagues outside science and engineering are beginning to realize that zero pollution doesn't exist and cannot be attained and that costs of removal of pollutants rises exponentially as the fractions of pollutants removed approach one.

The current emphasis on consumer protection, cleaning the environment, medical standards for workers, responsibility for products, and social concern for employees, neighbors, consumers, and the general public has had salutary effect upon textiles and the industry. First, the industry's record is a mixed bag in the area of responsibility. We yet have too many company towns, particularly where low taxes on the local industry is the first and last consideration. Fortunately, the virtual peonage of employees unable to escape company towns is long in the past in textiles, thanks to employee mobility and some competition for skilled workers. In general, except for generous adversity, the textile industry has not permitted itself to exercise the degree of responsibility it should. The industry has not led the way in noise control, flammability, byssinosis study, pollution control, safety, medical standards and help for employees, pensions, and disability benefits.

Government intervention has forced the industry to address a number of these problems. Results are better, costs much lower, dealings more pleasant, and ulcers and heart attacks many fewer if industry takes the lead in social responsibility instead of waiting to react to ill conceived demands forced upon industry by governments.

The textile industry hears the word, government, and runs for shelter. This conference is a case in point. Who are better informed and able to guide policy for textiles and textile materials than those who make these materials? Yet representatives of the textile industry are conspicuous by their absence. Some materials policy we shall have. If the textile industry does not help to formulate that policy all it can do is grouse about the poorer policy arrived at without the industry's expertise and judgment.

The textile industry's record is remarkably good in employment of members of minority groups. At the present time the limitation on advancement into higher paying, more responsible positions by minority group members is the lack of trained people capable of assuming these positions. The greatest choice in positions enjoyed by any group today is for blacks who are able and well educated in areas of need to the textile industrial complex. Placing blacks beyond their capabilities for appearance and to satisfy HEW destroys the dignity and respect of those advanced without merit and undermines the morale and decreases productivity of most workers.

The textile industry must come out of its shell. A few of the other parts of the textile industrial complex have emerged somewhat, but they must come further. Whether we like it or not, governments are our partners in running our shops as well as in enjoying the profits. Are we going to look at the government-industry interface only as an adversary relationship? Or are we going to recognize that we must help to guide government's dealings with out industry? Only by doing the latter can we survive.

National Goals

Our goal should be a vigorous, innovative, hard working, prosperous textile industrial complex which leads the world in materials, products, style, diversity, quality, efficiency, intelligent social concern, and offering products of maximum real value. This industry should be adequate to satisfy the nation's need in times of mobilized, maximum effort. The textile complex must be able to compete in the world market so that the U. S. can break even or enjoy a favorable balance of trade in textiles (Table XV).

Given the acceptance of this goal and the committment to reach it, establishing specific, attainable goals for materials and other engineering, scientific, and technical endeavor is easy. Attaining scientific and engineering goals usually is relatively easy compared to finding our way in human, political, industrial, economic, and international relations.

Policy and Program

The first need of textiles U.S. is for policy and programs. The U. S. has no textile policy and never has had a textile policy.

Compare the first two basic needs, food and fiber; compare policy for each. We have had agricultural policy; it must be considered excellent and spectacularly successful. From the Morrill Act of 1862, through the federal and state government supported R & D programs, the extension programs, and the conservation and electrification programs to the price support programs, the result of labors under this policy and resulting programs (and those of our neighbors to the north) is that the U. S. and Canada produce almost a quarter of the world's food for about six percent of the world's people and require only about three percent of the six percent to produce this bonanza. The only bright spot in policy and programs for textiles has been through agricultural policy for cotton. Cotton fiber has been improved continuously; USDA research has contributed substantially to some control of flammability, permanent press, and our knowledge of cellulose. Until this year with some import agreements, the only textile policy was that expressed in agricultural policy for cotton.

The U. S. should encourage textiles in the broad sense as it has agriculture. In order that this be done, the textile industrial complex and the U. S. Government must lay aside their adversary relationship and learn to cooperate. Each depends upon the other. Only by cooperation, as has been the rule in agriculture, can we compete with "Japan, Inc.," "Germany, Inc.," and others today and "Europe, Inc.," in years to come. That such policy and programs can work is amply demonstrated by agriculture, our best exporter and probably our most advanced, automated, sophisticated industry.

In textiles the U.S. program should assist and encourage R & D in textiles in a broad range of areas. The RAAN program of NSF and evolving successor programs can serve as stop gaps by assisting textile R & D until a broad program of textile research can be developed. Obvious areas of need are studies to make new fibers, in fact, a new generation of fibers, as well as studies of fibrous structures, new composites, new yarns and fabrics, new methods of yarn and fabric formation, new methods for forming garments, dyes and finishes, combustion and flammability, disposal and pollution, physiological effects, machinery and instrument development, etc.

Cooperative industry, government, and college and university efforts in R & D, engineering development, man-power training, management and sales studies, market development, and other areas should be developed immediately. Export of textiles should be encouraged in every reasonable way including tax incentives. Industry and government must and can cooperate to restore favorable balance of payments in textiles. To accomplish these goals reasonable tax policies are necessary. The textile industrial complex must be able to keep its plant modern, at least as modern as our Japanese competitors, for example. This requires tax policies which penalize obsolescence.

Regulation must be sensible. Industry is not the selfish ogre described in political hyperbole, nor is government the interactable, unreasoning tyranny industrialists in their cups imagine. Government needs help in regulating the textile industry. Able, trained applied scientists, engineers, textile technologists, managers, textile attorneys, etc., are needed to regulate, establish standards, and administer government agencies dealing with textiles. Further, government needs the advice and judgment of the textile industry to regulate sensibly. Survival requires it.

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TABLE I
A FEW TURNING POINTS IN TEXTILES

1738	John Wyatt and Louis Paul--drawing rollers
1738	John Kay--fly shuttle
1769	Richard Arkwright--spinning frame
1770	James Hargreaves--spinning jenny
1770	Thomas Bell--roller printing
1771	Richard Arkwright--first factory, a cotton spinning mill
1774	Edmund Cartwright--power loom, comber frame
1779	Samuel Crompton--"the mule"
1794	Eli Whitney--cotton gin
1801	Joseph Jacquard--punched card loom
1814	Francis Cabot Lowell--first complete textile mill
1854	William Perkin--mauve dye
1884	Hilaire Chardonnet--nitrocellulose fiber
1910	Samuel Salvage--first rayon produced in the U. S.
1930	Wallace Carothers and Julian Hill--drawing of fibers
1934	Wallace Carothers--nylon 66
1941	J. R. Whinfield and J. T. Dickson--poly(ethylene terephthalate)
1950	Sulzer Brothers--shuttleless loom

TABLE II
A FEW OBSERVATIONS ABOUT THE TEXTILE INDUSTRY

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- ✓ The textile industry is a textile-fiber-polymer-chemical-equipment-engineering complex of industries.
 - ✓ Textiles is the first mechanized industry.
 - ✓ Textiles is the first automated industry.
 - ✓ Textiles is the first industry forced to produce a large volume of goods in a diversity of materials, constructions, patterns, colors, etc.
 - ✓ Textiles is the first modern industry.
 - ✓ Textiles is one of the most highly developed, sophisticated industries.
 - ✓ Textiles have been around so long that we take them for granted.
 - ✓ Textiles "poor mouths" too much.
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TABLE III
PERCENT OF APPAREL EMPLOYMENT TO ALL MANUFACTURING
FOR SELECTED STATES IN 1967 (3)

	Percent of Apparel Employment	Rank of Apparel Employment in State
Mississippi	22	1st
Tennessee	16	1st
New York	16	1st
Georgia	15	2nd
South Carolina	13	2nd
Alabama	13	3rd
Kentucky	12	2nd
Pennsylvania	12	2nd
Virginia	10	3rd
Arkansas	10	3rd
North Carolina	9	2nd
New Jersey	9	3rd

TABLE IV
SOME PROJECTIONS--BORROWED FROM L. CHRISTIANSON,
EDITOR-IN-CHIEF, TEXTILE WORLD (5)

	Billions of Dollars			
	1971	1982	Increase	Double by
GNP	873	1477	69%	1986
Capital Expenditures	68	114	68%	1986
Consumer Expenditures	551	985	79%	1984
Federal Expenditures	72	120	67%	1986
Textile Sales	24	37	56%	1989

TABLE V
A FEW COSTLY ITEMS WHICH CAN LIMIT GROWTH

-
-
- ✓ "Belt tightening" to restor a favorable balance of payments, 1972-74.
 - ✓ Cost of energy and fuel, 1975 on.
 - ✓ Cost of cleaning the environment, 1974 on.
 - ✓ Higher costs of raw materials, 1973 on.
 - ✓ Rebuilding obsolete and obsolescent plants, 1973 on.
-
-

TABLE VI
TECHNICAL NEEDS AND REQUIREMENTS FOR TEXTILES

New Fibers

Cotton-like fiber, non-flammable
Inexpensive cotton-like fiber for export
Non-flammable fibers
True composite fibers
Stronger, tougher fibers at competitive, textile prices
Man-made wool, strong and tough
"Man in the White Suit" fiber
Inexpensive, high strength, high modulus, chemically stable fibers

New Fabrics

Woven, stretch fabrics
Improved blends--no "pilling," "frosting," etc.
Good feel and real comfort from synthetics
Three dimensional fabrics
Fabrics for structural elements in composites, suspension
and load-bearing systems, etc.
Faster methods of yarn formation
Faster weaving
Faster knitting

TABLE VII
TECHNICAL NEEDS AND REQUIREMENTS FOR TEXTILES

New Non-woven, Non-knitted Materials

Formed garments
New materials and methods for forming garments
Increased strength and toughness at low cost
More varied and better dyes, finishes, etc.
New disposal methods

New Composite Structures

New matrix materials
New fiber and composite treating materials
Textile and fiber structures for construction materials
A low cost glass fiber--polyester

TABLE VIII
A FEW TEXTILE RESEARCH PROBLEMS FOR 1972

True composite fibers--oriented, in situ polymerization,
precipitation of oriented polymers, etc.

Combustion and flammability

Programmed Degradation

New dyes and finishes

Triboelectric behavior

Plasticizing of fibers and polymers

Materials and methods in yarn and fabric formation

TABLE IX
TEXTILE ENGINEERING PROBLEMS FOR 1972

Mechanics research and equipment development and design
Textile and fiber instrument development
Mechanics of fibrous structures--design criteria and formulae
for fabrics, design of structural members from fabrics and
fibrous systems, new composites
Automation--design and weaving, spinning and weave rooms without
humans, trouble shooting
Noise and dust control
Air and water pollution
Waste disposal

TABLE X
TECHNICAL MANAGEMENT PROBLEMS FOR 1972

Control of production processes
Marketing methods improvement
Maximizing the time advantage of the domestic
producer

TABLE XI
NEEDS FOR MAN AND WOMAN POWER

Depends on import situation--women and semi-skilled workers are most vulnerable.

Numbers of semi-skilled workers will decrease.

Numbers of office workers, clerical, sales, marketing, management, etc., will increase slowly.

Textile chemists and engineers will be in increasingly short supply.

People with technical training in textiles probably will be preferred to others with comparable years of schooling.

Textile engineers and scientists, especially textile chemists, are needed for R&D and for government regulatory positions.

TABLE XII
NEEDED EDUCATION IN TEXTILES

Textile chemistry--colloid, organic, polymer and physical chemistry + chemical process engineering + textiles + textile processing.

Textile engineering--mechanical and chemical engineering + textiles + textile process engineering + mechanics of fibrous structures.

Textiles--textiles + textile processing + management.

Polymer and fiber science and engineering.

Technical management--marketing, control, etc.

Textile technology.

Continuing education.

TABLE XIII

EDUCATION IN TEXTILES--OFFERINGS AT GEORGIA TECH

<u>Degrees Offered</u>		
Textile chemistry	BS	
Textile engineering	BS, MS	
Textiles	BS, MS, PhD	
<u>Programs Offered</u>		
	<u>Bachelor's Level</u>	<u>Master's Level</u>
Textile chemistry	X	X
Textile engineering	X	X
Textiles	X	X
Polymer science		X
<u>PhD Areas of Specialization</u>		
Textile chemistry		
Polymer science		
Textile process engineering		
Mechanics of fibrous structures		

TABLE XIV
LEGAL, SOCIAL, ENVIRONMENTAL, AND MEDICAL IMPLICATIONS

Flammability standards--illogical in at least one case.

Labelling and guarantees of performance--questionable.

Pollution--cost rises exponentially with purity.

Responsibilities--consumer protection; cleaning the environment; products warranties; social concern for employees, neighbors, consumers, and general public.

Textile industry--generous to education.

Textile industry--slow on noise control, flammability, byssinosis, pollution control, safety, medical standards and help for employees, pensions, and disability benefits.

Textile industry--hears the word, government, and runs for shelter.

Textile industry--good record on employment of members of minority groups.

Textile industry--must come out of its shell.

TABLE XV
NATIONAL GOALS FOR TEXTILES

Vigorous, innovative, hard-working, prosperous textile industrial complex--

lead the world in materials, products, style, diversity, quality, efficiency, intelligent social concern, and giving maximum value,

adequate to satisfy the nation's needs in times of mobilised, maximum effort,

able to compete in world market.

TABLE XVI
A POLICY AND PROGRAM FOR TEXTILES

No textile policy at present or in past.

Contrast food and textiles for policy and programs.

Need textile policy--encourage and abet textiles in broad sense as agriculture has been encouraged.

Government should encourage and help R&D--need new fibers, new composites, study of fibrous structures, new methods of yarn and fabric formation, new methods of forming garments, new dyes and finishes, studies of combustion and flammability, methods of disposal and control of pollution, study of physiological effects, machinery and instrument development, etc.

Government should encourage exports--tax benefits for export, tax penalties on obsolescence, etc.

Regulation must be sensible.

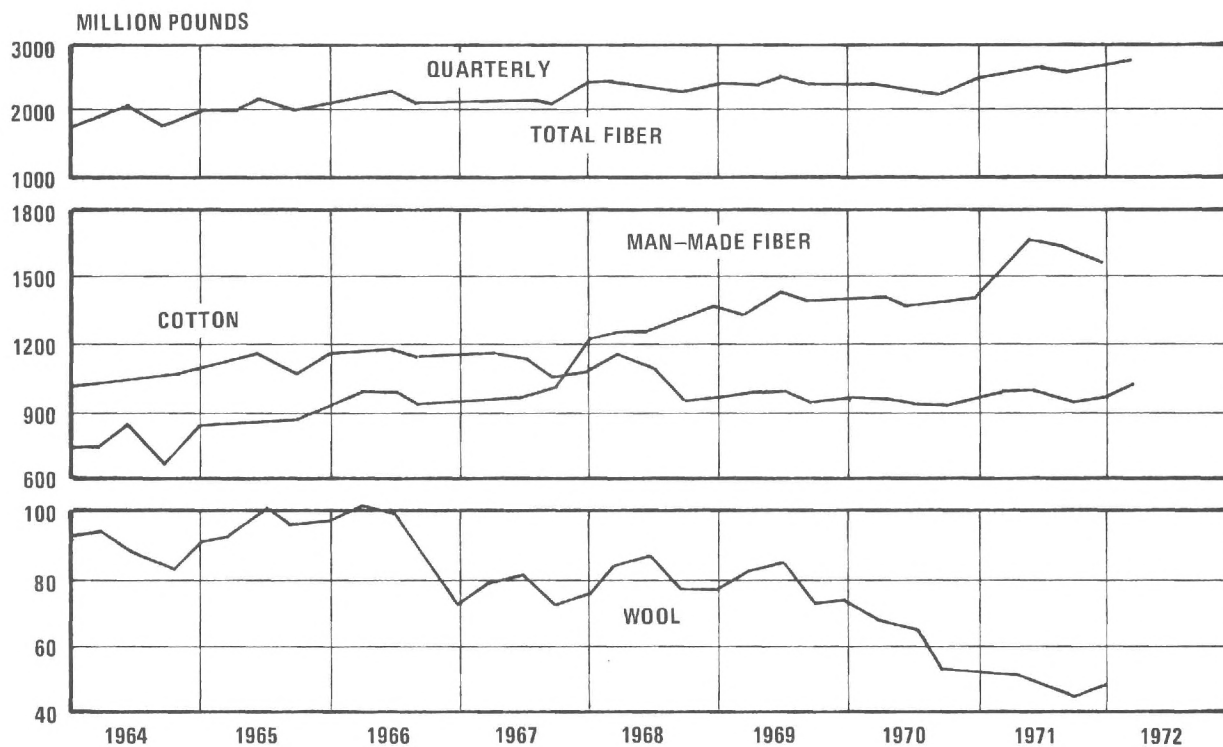


Figure 1. Total Fiber Consumption by U.S. Textile Mills (in Millions of Pounds)'
 (Noncopyrighted material reproduced from Textile HI-LIGHTS June, 1972,
 with permission from the American Textile Manufacturers Institute, Inc.)

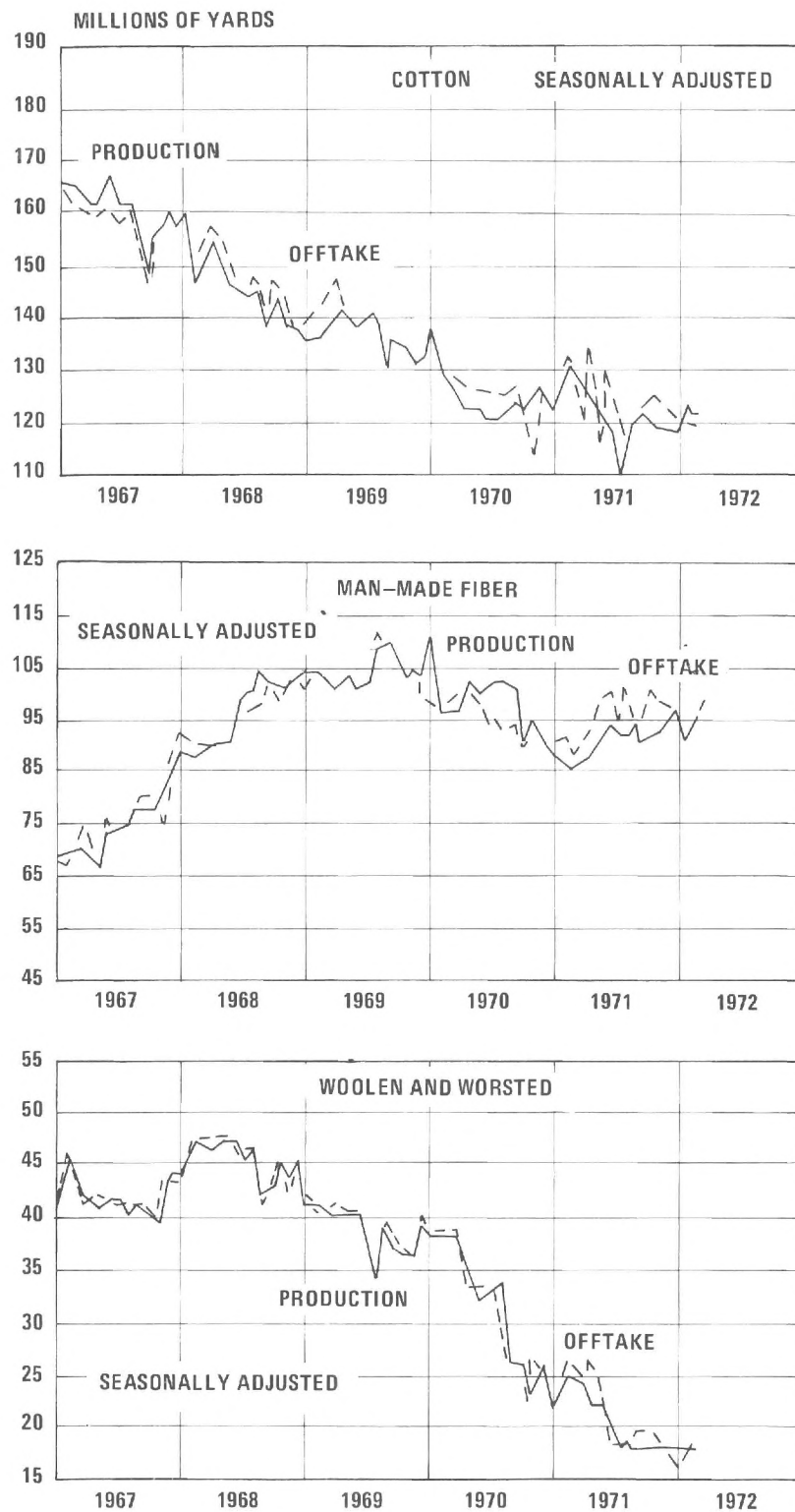


Figure 2. Gray Goods Production (Weekly Average - Millions of Linear Yards)
 (Noncopyrighted material reproduced from Textile HI-LIGHTS June, 1972,
 with permission from the American Textile Manufacturers Institute, Inc.)

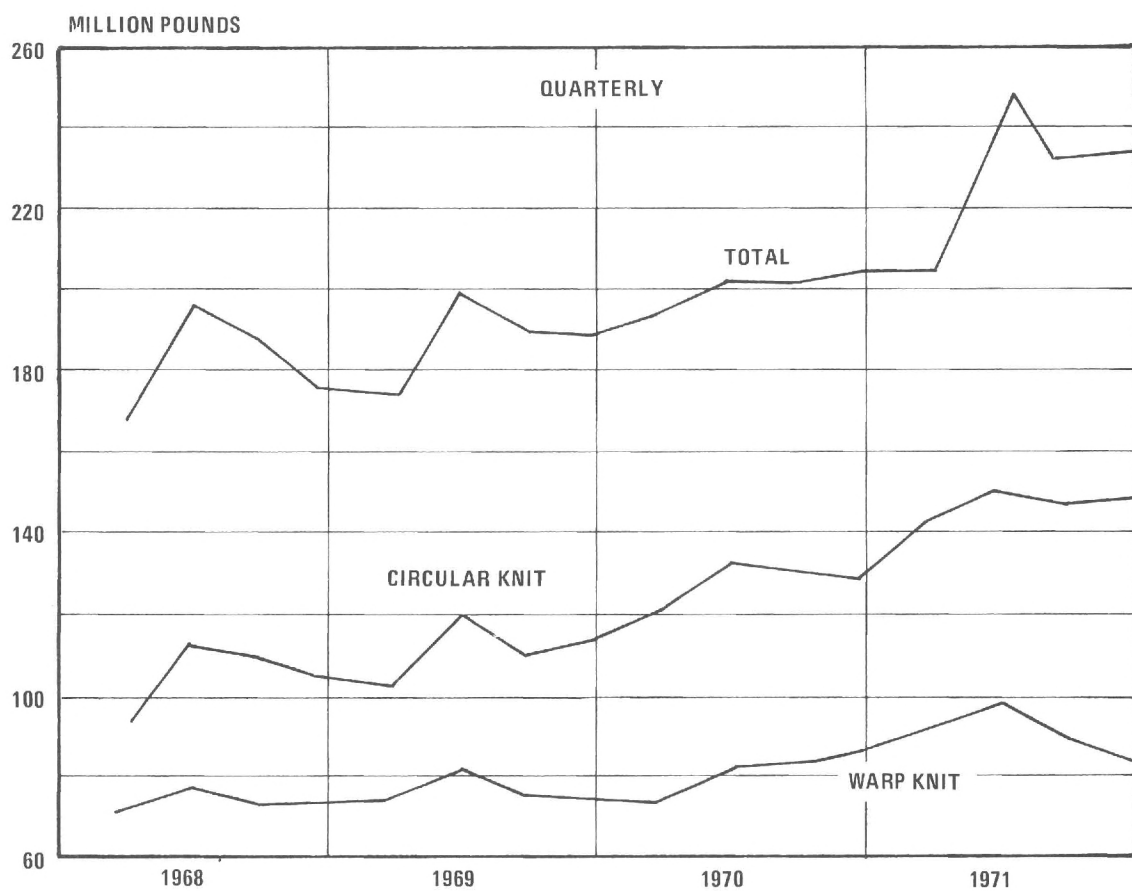


Figure 3. Shipments (Knit Cloth)
 (Noncopyrighted material reproduced from Textile HI-LIGHTS June, 1972,
 with permission from the American Textile Manufacturers Institute, Inc.)

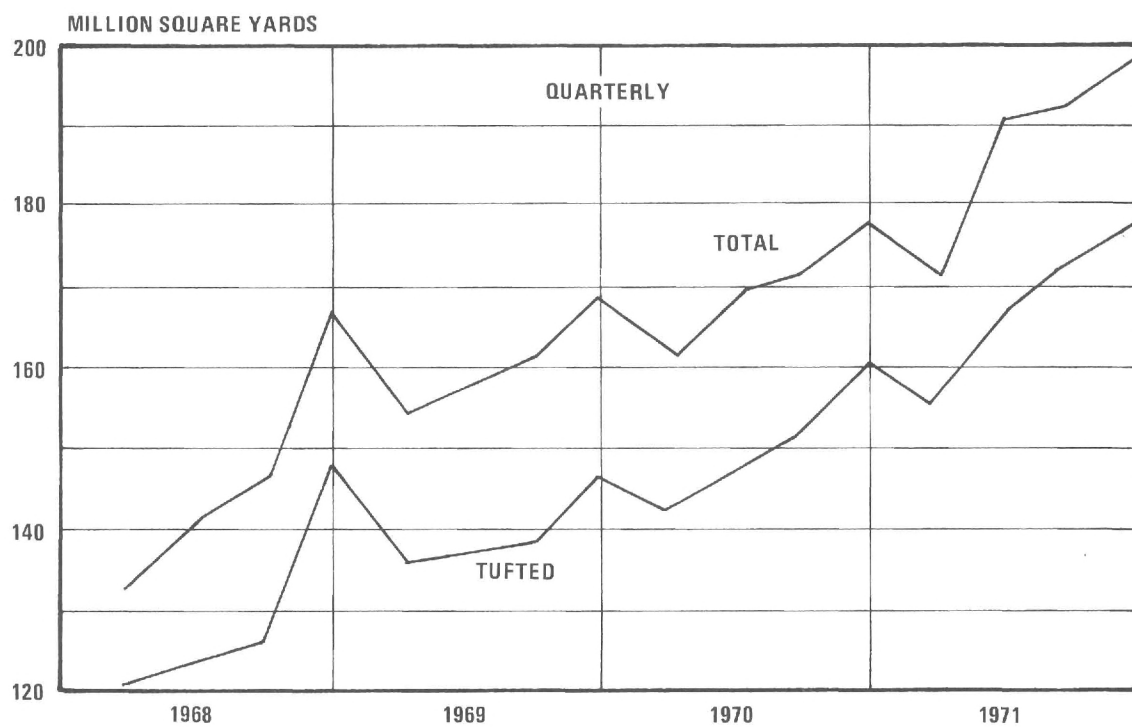


Figure 4. Shipments (Rugs and Carpets)
 (Noncopyrighted material reproduced from Textile HI-LIGHTS June, 1972,
 with permission from the American Textile Manufacturers Institute, Inc.)

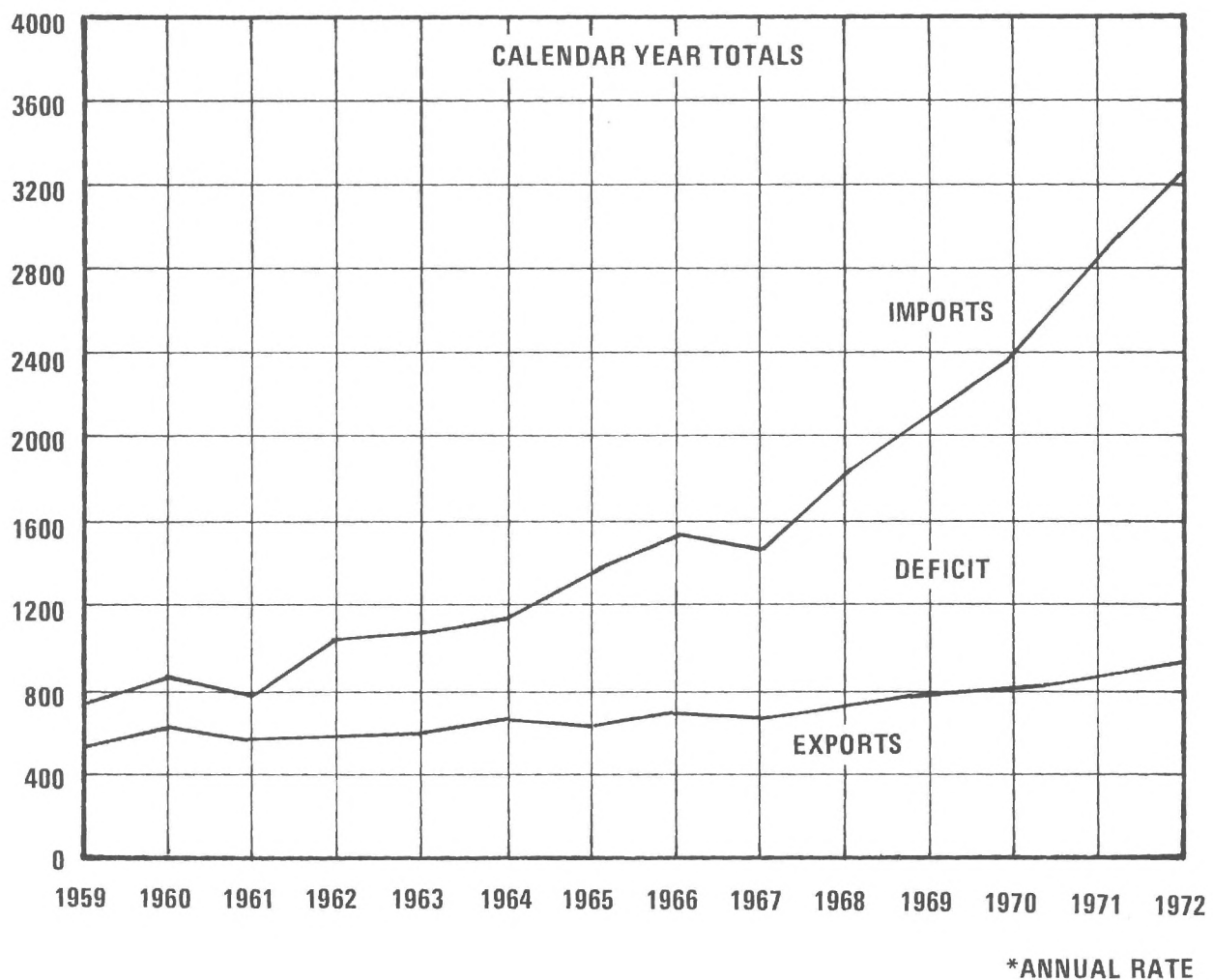


Figure 5. U.S. Textile Trade (Millions of Dollars)
 (Noncopyrighted material reproduced from Textile HI-LIGHTS June, 1972,
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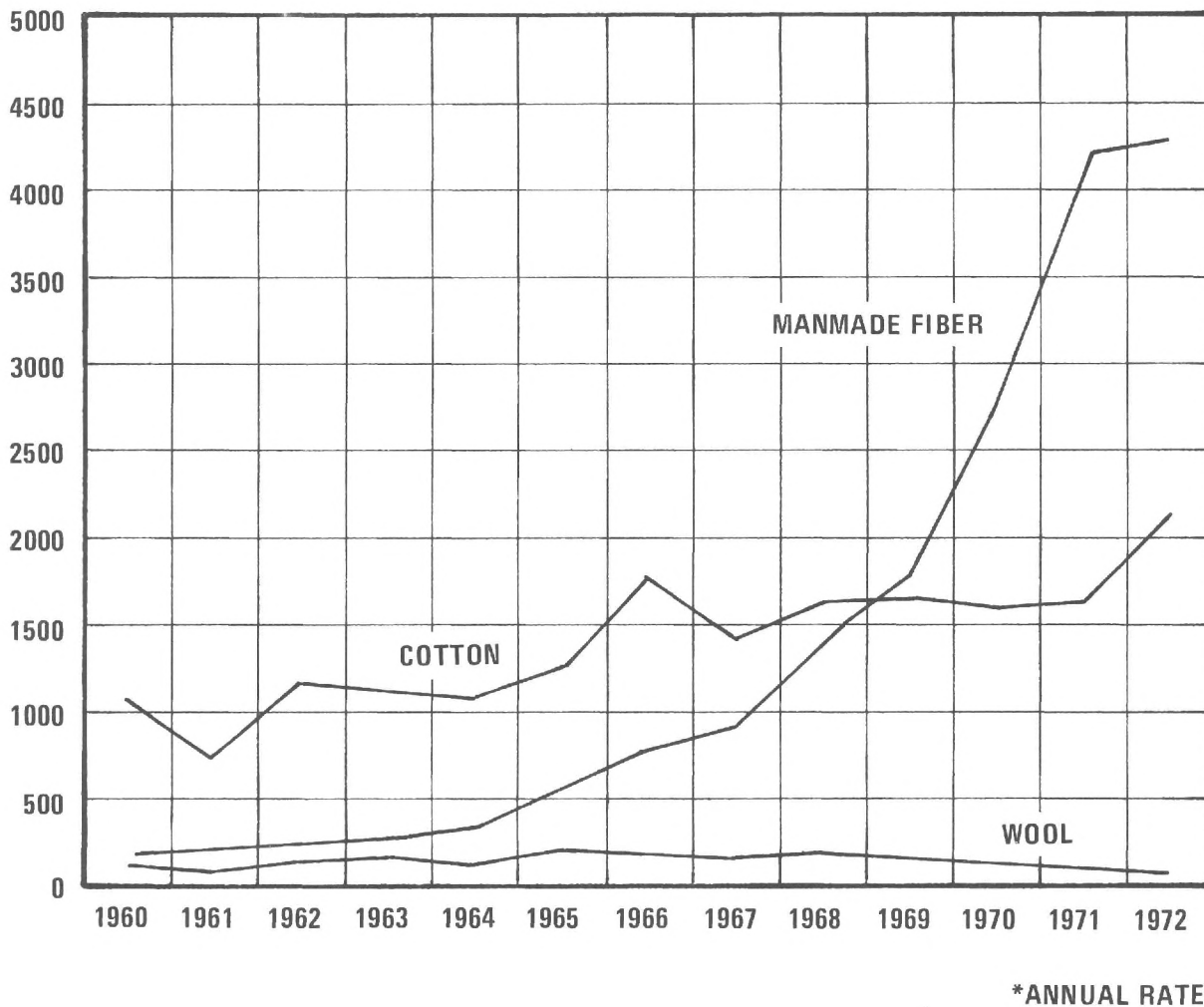


Figure 6. U.S. Imports of Textile Manufacturers (Millions of Equivalent Square Yards)
 (Noncopyrighted material reproduced from Textile HI-LIGHTS June, 1972,
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FOREST MANAGEMENT AND LAND USE CONFLICTS:

A CASE STUDY OF RESOURCE MANAGEMENT^{*}

by

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ABSTRACT

Social institutions encourage, direct, constrain, and limit the availability, flow, use and disposal of all materials. This presentation reviews hypotheses and findings from a study in progress of the social and institutional impacts on availability and use of one set of materials, forest products. The study concentrates upon the principal federal land management agency, the Forest Service, and its interactions with its principal constituencies, the private environmental organizations and the forest products industry.

Sources of the present conflict over uses of the public forests include steady shrinkage in productive land areas, growth of an urban population with increasing leisure time, the declining supply of privately-owned sawtimber, and the resulting pressures to increase timber harvest on public lands. The increasing use of intensive management practices and technology by both private and public forest managers to extend commodity supplies is opposed by conservation and environmental groups. These new constituencies for the forests' amenity values attach growing importance to non-commodity uses of the forests. Perceived environmental impacts of intensive forest management are a source of conflict, as are existing institutions which manage or affect forest resources.

The issues in the conflict over forest management are the status of de facto wilderness areas in the national forests, environmental and amenity impacts of intensive management, the locus of decision-making power concerning

^{*} Research sponsored by the National Science Foundation RANN Program under Union Carbide Corporation's contract with the U. S. Atomic Energy Commission.

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uses of the forests, and numerous arguments over the meanings of multiple use and sustained yield as tenets of policy. Multiple use analysis still founders on the lack of a common scale for comparing amenity values with commodity values. Arguments over sustained yield in the forests are distilled to the question of how "allowable cut" determinations are made.

The institutional setting of the conflict involves attitudes and values concerning forests and land use in the United States, and those institutional structures (taxes, credit, insurance) which affect management by the private owners who control 73% of the commercial forest land. The structure and functioning of the Forest Service bureaucracy is examined in relation to management of public and private forests for multiple uses and for sustained yield of the forest resource. Lack of institutional mechanisms for resolving multiple use conflicts results in resource use decisions made according to the faith and value judgments of professional foresters. The extensive "perception differential" between foresters and the public represents a value conflict among constituencies with differing access to decision-making power in the Forest Service and in government. Resource allocation decisions by the Forest Service have been significantly affected by changes in forestry education, constraints imposed by the federal budgeting process, and limits imposed by Congress and public opinion upon the extensive discretionary powers of the agency.

The role of technology in the conflict has been to expand the commodity base at the expense of amenity values of the forest resource. Use of new silvicultural technology has upset the previous balance between roughly co-equal uses, giving a primary role to the commodity functions of forest management. Existing institutions have been inadequate to direct the technology or to mediate the new difficulties posed for multiple use decisions by adoption of powerful new technologies such as extensive clear-cutting, new modes of artificial regeneration, and chemo-forestry. The current conflict over forest management can be interpreted as a "citizens technology assessment" arising out of loss of confidence in the professional managers.

Policy questions raised by the analysis are listed. Possible resolutions of the conflict include various measures to increase commodity supplies (re-forestation, institutional innovations for private non-industrial woodlands), to decrease demand for virgin material (recycling, increases in utilization), and to provide basic data for decision-making through research. Changes in institutional arrangements to permit and encourage these developments might include comprehensive land use regulations, mechanisms for public participation in decision-making, and institutional arrangements to permit sustained yield and multiple use management on all types of ownerships. The ecosystem approach to comprehensive systems management has possibilities for better mediating multiple use conflicts in management of the forest resource.

INTRODUCTION

The 1970's are already commonly called "the environmental decade." They may well be remembered best, however, for another related characteristic: the

dawning recognition that we are seeing the end of our society's spectacular "free fall" with respect to resource use. A variety of constraints upon use and availability of resources is appearing, of which the National Environmental Policy Act of 1970 is only one. Our concerns over pollution and the energy crisis, for example, will have profound effects upon our economic and social structure before long, partly because of the attempts to resolve the inevitable conflicts over scarcer resources and their sometimes incompatible uses.

One of the goals of the National Commission on Materials Policy is to "identify the relationship of the broad subject of materials in all their aspects to national goals and objectives." This paper makes the additional assumption that materials should serve the full spectrum of human needs. Whether they do or not, of course, depends upon the social institutions which direct and limit their use, and how we define human needs.

This paper presents a general overview of some resource management considerations relative to forest in the context of the current social conflict over how the public forests should be used. It considers ideas, hypotheses, and findings from a study in progress which attempts to define relationships between the social conflict, technology, role of the professions involved in management of resources, availability of resources, and the public and private institutions whose decisions affect forest management. The study shows how social considerations can limit the availability of material resources for commodity uses, how redefinitions of public goals can alter the resource picture, and raises the broad policy question of how the forests shall be used.

The current trial by combat in the political arena and the courts over these goal questions occurs because of lack of consideration of materials use in the wider social context. The conflict deepens because of lack of adequate mechanisms to resolve multiple use conflicts in the face of growing demands on the forest resource.

SOURCES OF THE CONFLICT

The sources of the conflict over uses of the public forests range major to minor in their prevalence and impact. Population growth and redistribution through urbanization, the steady shrinkage in productive land area, and depletion of forests are worldwide phenomena. Their effect in the United States has had unique patterns and results due to the extraordinary quantity of high-quality forest land available to European settlers; and the development of attitudes and institutions which encourage rapid exploitation of land and resources.

Depletion of the U. S. timber resource, especially on the earlier-harvested private lands, has resulted in growing pressure on the public lands, until more than a third of the total cut comes from the 19% of the commercial forest which is national forest (Public Land Law Review Commission, 1970). Net growth exceeds cut only recently (1960) and temporarily. The U. S. Forest

Service (USFS) estimates that cut will again exceed growth for some types of wood within the decade (Lassen and Hair, 1970). While quantity of wood grown is up recently, quality is still declining, with much growth occurring on culls, "undersirable species," or on very small stock (USFS Timber Trends, 1965; Hearings, p. 857, 1971).

The demands for more services and commodities from the forests continue to grow, however, pressing upon a non-expanding resource base. In the forest products sector, total demand has held roughly constant for many years, though the rapidly growing paper and plywood segments are expected to push total consumption upward steadily in the future (USFS, Timber Trends, 1965; Cliff, 1969). At the same time, several other major uses of the forest, often as a complete ecosystem, have risen markedly in importance. Water, recreation, wildlife and wilderness values have both amenity and commodity importance, with recreational use of the forest growing at 10% per year for three decades (Clawson and Held, 1957).

The adoption of intensive management techniques to increase wood production from the public forests as has been done with industry-owned forests is another source of the conflict. Widespread public protest such as has been heard in the Congressional "clearcut hearings" of 1971 concerns use of clearcutting, artificial regeneration, terracing, monoculture, chemo-forestry and prescribed burning as tools for intensive management. The perceived environmental impacts of these intensive management practices figure importantly in the public protest, since these impacts are seen as damaging the non-commodity values of the forests. New constituencies among the affluent, urbanizing population have developed in past decades to promote and protect these non-commodity values (Harry, et al., 1969) which are seen as being gravely threatened by intensive forest management.

Finally, the social institutions which determine forest resource management strategies, and the attitudes and values which support them are both sources and issues in the conflict. The conflict arises in part because of policies formulated or implemented by present institutions. In some areas, the lack of institutions and policies is another source of conflict. For instance, the decisions made by the millions of small forest owners reflect the lack of land use planning and the unavailability of credit and insurance for sustained yield forest management, thus placing greater demands upon the public forests. New institutional arrangements are sought by proponents of change while old ones are defended by those benefiting from the present allocation of benefits from the national forests.

ISSUES IN THE CONFLICT

The major issues in the current debate over national forest management are the status of de facto wilderness areas, the ecological and amenity impacts of intensive management techniques such as clearcutting, the locus of decision-making about uses of the national forests, and the meaning of current policies of multiple-use and sustained yield. The non-issues in the debate (depletion and public regulation) are also significant.

De Facto Wilderness

Much public protest centers upon the newly-vulnerable status of de facto wilderness areas. Following an extensive road building program within the national forests, previously inaccessible areas are subject to logging. A study of past Forest Service policy indicates that these areas remained undisturbed not by choice, but largely because of the unavailability of economic harvesting technology and lack of roads (Harper and Rettie, 1946).

In addition, the Forest Service has reclassified large areas of forest in the past 25 years, removing them from their protected status as non-commercial lands. Since 1946, the area designated as commercial forest has increased from 78 million acres to 97 million acres (1968), with no significant change in the total area of the national forests. The Forest Service says the increase represents changes in "merchantability and operability of timber on the ground" (Cliff, 1971, p. 839). The steady decline of virgin woodland continues, with about 30 million acres of commercial forest land remaining (Van Sickle, 1971) of the original 1.1 billion acres of woodland covering the United States in 1700.

Intensive Management

The greatest volume of protest concerns the impact of intensive management techniques such as clearcutting. Nearly 200 witnesses testified or wrote to the 1971 "clearcut hearings" on management of the public lands. They protested the 1964 Forest Service adoption of clearcutting* as a preferred harvesting and regeneration technique, and claimed devastating environmental and amenity effects (Hearings, 1971). Most foresters claimed that clearcutting simulates natural events essential to reproduction of desired species (Davis, 1971; Duffield, 1971; Forest Industries Council, 1971). Official inquiries into forest management practices include investigations by the Forest Service, a university group, and the West Virginia Legislature into operations of national forests in Wyoming, Montana, and West Virginia (Bolle, 1970; USFS Bitterroot, 1970a; USFS Wyoming, 1971a; West Virginia Legislature, 1970). Protests of the "agriculturalization of the forests" are directed at the regeneration practices involved after clearcutting (terracing and scarifying to permit replanting of steep slopes as in the Bitterroot National Forest) (Margolin, 1970; Larson, 1971). Modern mechanized logging and attendant road building result in extensive soil disturbance and water pollution (Ray, Environmental Protection Agency, 1971), while clearcutting on some soils disrupts nutrient cycling (Bormann, 1967).

Multiple-Use and Sustained Yield Definitions

The differing meanings of multiple use and sustained yield are another major issue. Conservationists protest clearcutting as a violation of multiple use, while the Forest Service and forest products industries argue that

* Eastern national forests became subject to clearcutting in 1964, as western national forests have been for some time.

cutting is essential to bring more areas into "multiple use" and under sustained yield management. Foresters and others are questioning the usefulness of the vague term "multiple use" (Sterling, 1970; Davis, 1969; Reidel, 1971). Forest Service management practices and "allowable cut" guidelines are challenged as being incompatible with sustained yield management (Robinson, 1971; Stoddard, 1971) while the Forest Service claims a substantial unused backlog of allowable cut for 20 years (Hearings, p. 838, 1971).

The problem centers in different views of how forests should be used. The Multiple Use-Sustained Yield Act of 1960 merely listed a variety of uses of the national forests: it did not define a balance of uses nor procedures by which a balance might be devised. Defining the balance of uses is left to the discretion of the Forest Service. The issues concerning multiple use and sustained yield thus involve dominant use vs multiple use, intensive use vs extensive use, and how to reconcile incompatible uses. Some as-yet-unanswered questions of fact are involved in the charge of environmentalists that Forest Service management violates sustained yield of the forests. The long-term effects of clearcutting, large-scale soil disturbance, herbicide use, etc., are not known.

Locus of Decision-Making Power

A principal aspect of the conflict is the growing argument over the locus of decision-making power. A vocal segment of the public has lost confidence in and is challenging the policy-making of the professionals (foresters, Forest Service administrators) as being production oriented, and thus willing to employ environmentally-damaging technologies to increase short-term production efficiency (Sierra Club, et al., 1970; Eisler, 1971). Environmental and preservationist groups seek to change policy and practice through protests, legal action, and federal legislation. Similarly, the forest products industry seeks to expand its raw material supply by political means at the executive and congressional level. They urge increased cutting on the national forests, seek to protect their right to employ clearcutting technology, and defend the Forest Service from criticism (Hagenstein, 1970; Kenworthy, 1972; New York Times editorial, 1972).

Responses of the Forest Service to date include organizing an elaborate series of public hearings and "listening sessions" on the development of land use plans for local and regional administrative levels, while reserving to itself the decision-making power (USFS, Appalachians, 1971b).

All of the current issues in the debate over forest management are relatively recent ones, having become major issues in the past decade. The climate surrounding passage of the Multiple Use-Sustained Yield Act of 1960 was different from that now, though some current issues were clearly foreshadowed then (Crafts, 1970a, 1970b; McArdle, 1970). Largely absent from current debate are two issues prominent for 50 years in past discussions of the role of public forests. These are the public interest in management of

private forests, and depletion of the national timber supply (Greeley, 1922; Clapp, 1949; Marshall, 1930). An interesting reversal of positions finds the Forest Service now defending clearcutting as silviculturally sound* whereas the Service formerly sought its prohibition except under limited conditions (Watts, 1944).

PRINCIPAL ACTORS AND THEIR PERSPECTIVES

Those involved in the arguments over use and management of the national forests range from major protagonists like the United States Forest Service, a variety of conservation and environmental groups, and the forest products industry, to individual participants who express their views at public hearings or in court. Their distinctive perspectives of the issues are here briefly reviewed.

Unseen but significant actors include the 4.5 million small owners of 60% of U. S. commercial forest lands, whose land-use decisions ease or increase demands made upon the public forests.

Private Forest Owners and Managers

Private forest owners control 73% of U. S. commercial forest land, including a high proportion of the best timber sites. Among small owners, however, whose average holding is under 100 acres, very little timber management is practiced. Sustained yield forestry is far from a reality on most of these lands, despite decades of efforts by the Forest Service (Stoddard, 1961). Most of the 300 million acres of commercial forest land (about 40%) in need of restocking, erosion control, or other treatment is privately owned (USFS, Incentives, 1970b). Other objectives such as recreation, pride of ownership, or investment for future non-timber use often rank higher with small forest owners than timber management (Nelson, 1971).

The large industrial forest managers own 13% of the commercial forest land, including the most productive and best located sites. With maximum production of wood fiber being the prime objective, these lands are intensively managed with all the modern technology of cropping. They produce an average of 52 cubic feet of wood fiber per acre per year (Hearings, p. 857, 1971), substantially more than that produced on either federal lands or small privately-owned lands where other objectives are also considered. While many large and/or corporate owners now manage their crops on the sustained yield principle, this change occurred only in recent decades when rising stumpage prices and changes in tax treatment (see Institutional Arrangements) made it economically profitable (Guthrie and Armstrong, 1961). Some of the large forest owners are vertically integrated from forest to final finished wood or paper product in order to take advantage of existing economic structures.

* This reversal occurred after reviewing regeneration results on test plots harvested by different methods.

United States Forest Service

Chief among the federal forest land managers is the U. S. Forest Service, which is mindful of its proud history since its organization upon present lines in 1905 by Gifford Pinchot, and steward of 183 million acres of national forest land including 97 million acres classified as commercial forest. As the largest agency of the Department of Agriculture, it conducts a varied program of field and research work with 22,000 employees (plus an equal number of seasonal workers) on a half-billion dollar annual budget. The Forest Service is a classic line-organized, functionally-oriented bureaucracy, notable for its geographically decentralized operation of the 154 national forests, and its organizational integration and esprit de corps (Kaufman, 1960; Frome, 1971).

Given sweeping powers by Congress through the vague definitions of the Multiple Use and Sustained Yield Act of 1960, the Forest Service is charged with "best meet(ing) the needs of the American people" in ways largely of its own choosing (Reich, 1962).

The past two decades have seen the apparent adoption of economic efficiency criteria by many Forest Service personnel, with a resulting emphasis upon the commodity functions (primarily timber) of the Forest Service. One rationale for clearcutting, adopted by the Service as favored harvest technique for both eastern and western forests 1964-1971, is that it is more efficient and allows the utilization of larger machines. The USFS notes that while only 37% of the harvested national forest area was clearcut, that area produces 60% of the annual wood volume (Hearings, p. 913, 1971). A large proportion of the published forestry and Forest Service literature since World War II concentrates upon ways to increase economic efficiency in timber management through various technologies (as examples, see Marty, 1969; Boe, 1963; Grano, 1970; Bengston, 1971).

A marked "perception differential"* exists between the advocates and opponents of intensive forest management, clouding the issues and impeding their clarification. In this argument, the lines are drawn more between professionals (mostly foresters) and non-professionals. Thus, the Forest Service appears to "talk the language" of the forest industry and have similar difficulties in comprehending the environmentalists and preservationists.** Foresters speak of "overmature and decadent" trees needing harvest, of the "problem of virgin forests," and of the economic waste of wilderness "offset by no tangible public benefits" (Cliff, Hearings, p. 808, 1971; Reich, 1962).

* I am indebted to Frederick Carlson who used this term in a letter to J. Forestry 69(9):545, Sept. 1971.

** Of course, not all foresters fit neatly into this category. Many of differing opinions have expressed themselves privately to individuals outside the Service (see Gordon Robinson, 1971). In addition, a substantial number of ex-Forest Service employees have expressed themselves in the Clearcut Hearings in terms critical of present trends.

They look for new technologies which will increase their control over nature, preferring simplified ecosystems which are more amenable to manipulation by man. The Forest Service sees itself as protector and guardian of the forests, preventing both their rapacious use and their "lock-up" by those opposed to "wise use." Clearcutting is viewed as a vital tool resulting in only "temporary visual impacts" necessary to produce a new crop of "thrifty, young trees" (Cliff, 1971). Foresters discuss trees as "efficient production units" (Nelson, 1967; Shirley, 1964). A firm belief in growth (of trees, production) as a goal to be maximized is affirmed by most professional foresters and industry, while the goals of the preservationists to "lock-up" more wilderness are seen as allowing the "unmanaged old growth (to) choke the forest . . . with death and decay" (Scott Paper Company, 1971). Foresters cite the current national excess of net growth over total cut as one evidence of their proper stewardship (American Forest Institute, 1971). At the same time, inadequate restocking of the national forests (backlog needing reforestation is now 5 million acres) has long been accepted as "normal," both in and out of the Forest Service (USFS, Productivity, 1971c).

The most significant breakdown in communication between foresters and conservationists occurs in the areas of multiple use and desirable degree of management and use. Development of the forest resource for its "best use" is a goal enunciated by Gifford Pinchot 65 years ago and still mentioned regularly in Forest Service publications (USFS, Use, 1907). "Best use" in the case of conflicting interests is defined as vaguely then as now: "The greatest good for the greatest number in the long run" (Wilson, 1905). Foresters see more intensive management as an entirely proper way to increase growth and thus permit greater allowable cuts. The Forest Service officially views increasing allowable cuts as "indicators of productivity earned" through improvements in silviculture, utilization technology, merchantability and accessibility (Cliff, Hearings, 1971). New areas (de facto wilderness) are brought under "multiple use and sustained yield" in order to harvest them. Foresters are urged to "manage the ecology instead of letting it run rampant." (Hagenstein, 1971). Part of the perception problem is that what the non-professional sees as legitimate uses of the forest (enjoyment of the forest as a whole for its esthetic and spiritual values, preferably untouched by man), strikes the intensive-management-oriented forester as a "non-use" at best, and more likely, as romantic dilettantism. That rational adults would seriously propose such a "use" for the forests is incomprehensible to industry and barely comprehensible to the forestry profession. Industrial foresters see the conflict as one caused by a "small group of narrow, selfish elites" hostile to scientific management and to the "wise-use" concept of conservation (Kalmar, 1970; Benneth, 1967; Moshofsky, 1970). The setting and technologies are new, but there are many echoes of the development-preservationist arguments of Pinchot and John Muir over Hetch-Hetchy reservoir in California in the early 1900's.

Both Forest Service and industry spokesmen regularly cite the nation's need for housing as a justification for their efforts to increase wood harvest (Cliff, p. 10, 1969).

A major perception difference concerns the role of the Forest Service

as resource manager and decision-maker. The Service recognizes the need for more public participation and support, but reserves to its "scientifically knowledgeable" professionals these choices. Former Chief Cliff has claimed that resource-allocation decisions should be made by technically trained experts who weigh all the alternatives and become "decision-architects" (Cliff, 1971a; Cliff, 1971b; Connaughton, 1971). Real, though limited, efforts to involve the public in early stages of land use planning have been made since 1970, but no formal public rights in questioning, advising, or initiating forest management policy exist (Reich, p. 713, 1962). While the forest industries currently defend the Forest Service's right to make decisions (Kalmar, 1970), this support is relatively recent, coinciding roughly with the Forest Service's adoption of production-oriented goals.

Environmental and Preservationist Organizations

Private citizen groups such as the Sierra Club, Wilderness Society, and Friends of the Earth have grown significantly in the past decade while enlarging their roles as protagonists for wilderness protection, outspoken opponents of clearcutting, and critics of Forest Service management policies. They perceive the function and purpose of national forests in strikingly different manner than do the professional managers of forests. These groups urge the retention of wilderness areas for their unique spiritual, esthetic, and scientific values. They denounce monoculture and mechanization for their destructive impacts upon the diversity and stability of ecosystems and for their adverse esthetic impacts through destruction of visual diversity. As demonstrated in the Clearcutting Hearings of 1971, many people view the Forest Service interpretation of multiple use as a violation of the Multiple Use Sustained Yield Act of 1960, claiming that use of clearcutting makes timber the primary goal at the expense of other uses. Some environmentalists have charged that the Forest Service has made a mockery of multiple use in destroying the forests for the profit of the forest products industry (Evans, 1971). Clearcutting is viewed as a sacrilege at best--an exploitive technology-producing devastation which is largely irreversible (Wood, 1971). Those working to defend de facto wilderness regularly cite growing population, land-use pressures, and a changing society with changing needs and values to justify their contention that the forests are more valuable for their other uses than for timber. Through their efforts, some 10 million acres (mostly national forest) have been changed from "de facto" to protected status under the provisions of the 1964 Wilderness Act. This is about 15% of the 66 million acres of wilderness projected by Congress for protection in 1964.

This segment of public opinion seeks a more effective voice in decision-making about the forests. They challenge the Forest Service's right to make value judgements and set policy concerning resource allocation choices.

INSTITUTIONAL SETTING OF THE CONFLICT

The institutional setting of the conflict involves the significant

features of the institutional environment which affect the actors' ability to formulate goals, marshal resources, adjust to constraints and resolve conflicts. Cultural values concerning forests, wilderness, and land use are discussed below as background to the institutional structure affecting forest management decisions by small and large private forest managers as well as the Forest Service. Some of the constraints upon sustained yield forest management for both public and private forest management are outlined, as well as interactions between private and public forestry institutions and forestry education.

Attitudes and Values

The attitudes and values underlying our present patterns of land and forest use include the frontier ethos with its myth of inexhaustible resources and antipathy toward "unconquered" wilderness, as well as the American belief in progress (i.e., the welcoming of change and the expectation of modification in the landscape. Built into our history is a view of the forest devastators as heroic "nation builders" (Jenks, 1928). Most conservationists of the last century, while instrumental in establishing public management of a remnant of the forests, deplored the destruction and waste of that era only because it was "inefficient" use of the resource (Hays, 1959).

"Highest and best use" definitions of resources have until recently always included manipulation for man's use. Most Americans have approved resource allocation made entirely by economic criteria. Land has risen in (economic) value according to man's changes and impact, proximity to denser populations, and the degree of alteration from its natural state (Clawson, 1965). Such a valuation system rates forestry as the lowest-priority land use.* Those opposing present forest management practices increasingly value forests and land for their intrinsic and even symbolic value (Lucas, 1966) rather than their instrumental value (for money or goods production). Whether the public forests will come to be valued primarily for their amenity opportunities rather than their commodity values (Crafts, 1970c) is at the heart of the current conflict over uses of the forests.

Some Institutional Arrangements Affecting Private Forestry

Unlike the large forest owners, most of the 4.5 million small forest owners are unorganized and inactive, with little influence upon the institutional structures which affect their lands and the values they receive from them. Not only the Forest Service but various state agencies have tried with but small success to interest small forest owners in more efficient timber management. Many states have revised their land taxation practices with only minor effect on the restocking, repair, or management of these lands (USFS, Tax, 1967). Credit or insurance for improved forest management is difficult for small owners to obtain, while inheritance and general property taxation practices continue to mean sudden land use changes for this type of

* At the bottom in all land-use classifications is desert or wasteland. Some classifications rank "grazing" below forest use in value.

forest land (Stoddard, 1961; RFF Committee, 1958). The introduction of depletion allowances and capital gains treatment (1944) has been a major incentive to large corporate owners, while the small forest owners are almost unaffected by the change (RFF Committee, 1958). Not surprisingly, less than one-fifth of small forest owners gave top priority to timber or wood production in a recent TVA survey (TVA, 1969).

The fact that land is more marketable as a commodity in the United States than in almost any other country (Yoho, 1961) is due in part to a lack of development of social institutions which elsewhere restrict the speed of land use changes. The need for "liquidity" in land holdings hinders the development of the long-term stability required for sustained yield forestry, one reason for the singular lack of success of cooperatives and management subsidiaries among small owners in this country (Stoddard, 1961; Yoho, 1961; Dempsey, 1969).

The prime beneficiary of the extensive federal subsidy of private forestry appears to be primarily the large commercial owners. Federally subsidized or cost-sharing programs include fire protection, one of the first programs authorized in 1911, as well as the more recent programs of insect and disease protection, and Forest Service research. Much of the latter is aimed at lowering the cost of wood production or improving the functioning of wood as a commodity.

All private forest ownerships account for 73% of the commercial forest land in the U. S., including the best timber sites, and the lion's share of lands in need of repair or restocking. Yet they are increasingly unable to fulfill either the commodity or amenity demands of the American public. The institutional arrangements which permit or encourage this situation thus contribute to the growing pressures upon the public forest lands.

Institutional Arrangements Affecting Public Forestry (USFS)

Among the many institutional arrangements which affect the Forest Service, the most pertinent to this conflict appear to be two: 1) the sweeping discretionary powers given to the Forest Service through the Multiple Use-Sustained Yield Act to determine the balance of uses, and 2) the nature of the federal budgeting process which usually means fiscal starvation for long-term agency needs and encouragement of short-term returns to the federal treasury (Clawson, 1951).

Discretionary Powers of the Forest Service

As previously discussed in the "locus of decision-making," the Forest Service has enlisted outside comment upon its recent land use planning actions, but reserves to itself the power of decision-making. One recent restriction upon that decision-making power appeared in the 1972 Senate Subcommittee on Public Lands' Clearcutting Guidelines, issued as a result of the 1971 Clearcutting hearings. In these guidelines, some limits are put upon the Forest Service power to decide among the balance of uses.

Another result of the recent public criticism of USFS management policy is several announced changes in those policies. These include admission of serious flaws in management plans and attitudes, discussion of how USFS programs came to be "out of balance" (see budgets in next section), self-imposed restrictions upon clearcutting, a nationwide silvicultural review, changes in road design specifications, and pledges of more public participation and environmental sensitivity (Hearings, pp. 909-914, 1971; USFS, Wyoming, 1971a; USFS, Bitterroot, 1970a).

Despite extensive use of the terms "multiple use" and "sustained yield," the organizational structure of the agency does not reflect any particular impact of these goals. No formal mechanisms exist for resolving multiple use disputes. Sustained yield management units, an institutional innovation authorized by Congress in 1944, have never been expanded beyond the few such units created before 1950. Only one cooperative management unit and five federal units have been created (Guthries, 1961). In addition, almost 90% of the professional personnel are foresters or engineers. The increasing use of other relevant professions has been pledged in response to criticism. Since 1965, the USFS has doubled its professional nonforester personnel (to 700) while the number of foresters dropped by 3%. The use of landscape architects, for instance, in planning clearcutting has increased rapidly (USFS, Productivity, 1971c). The importance of other disciplines in planning and executing a multiple-use approach is achieving some recognition in the Service.

Impact of Federal Budgeting Process

Forest Service budgets in the past decade show a remarkable difference between proposed and appropriated budgets. Timber management and related activities (road building, control of destructive agents like fire, insects, and disease) received 95% funding at the requested level, while other non-commodity uses of the forest (recreation, watershed protection, wildlife, and reforestation) received about 45% of funding at the requested level (Hearings, p. 196, 1971). This is in part a measure of the effectiveness of the timber constituency in Congress and the Executive Branch (Frome, pp. 162-163, 1971) as well as a measure of the ineffectiveness in that period of the non-commodity forest constituency. In the same period, foresters both inside and outside the Service began to protest the doubling of allowable cut quotas since 1950, as well as the replacement of sustained yield guidelines with the larger "allowable cut" quotas (Stoddard, pp. 134-137, 1971). Meanwhile, advancement within the agency began to be tied to success in meeting timber cut quotas (Crafts, p. 58, 1970c). Other examples of the impact of the timber constituency include presidential statements and executive orders urging increased timber harvest issued in 1970 and 1972 (June 19, 1970 and March 1972), despite defeat of the National Timber Supply Bill in Congress in 1970.* Joint

* The House of Representatives voted not to consider the bill (228-150) on February 26, 1970.

action of the many USFS constituencies of forest products, wildlife, and environmentalists may result in funding of the long-neglected reforestation and other multiple-use programs. Led by the American Forestry Association, an old line conservative and "wise-use" group, a joint approach to Congress has been undertaken in support of this objective (Towell, 1971). The AFA notes, however, that past budget increases above administration recommendations have been withheld by the Office of Management and Budget even when appropriated by Congress (Towell, 1971).

Other Institutional Arrangements

Other institutional arrangements affecting public forestry include the continuing changes in forestry education and the increasing use of legal mechanisms and court challenges by the environmentalists challenging USFS decisions.

Agency infallibility has been challenged successfully in the courts recently. The relaxation of the rules concerning the public's "standing to sue" has made agencies, including the USFS, accountable for their administrative actions (Curlin, 1972). Enlarged grounds for such suits include "aesthetic, conservational, or recreational" reasons.

With the increasing demand by industrial forestry for trained personnel after World War II, the content and focus of forestry education underwent significant change. The courses became more detailed and specialized, with greater emphasis upon economic criteria (Stoddard, 1970). The "generalists" of the USFS's early days were gradually replaced by better but more narrowly trained specialists in timber production, just as the demand upon the public forests were increasing in complexity and variety. Toumey's 1928 chapter on "forest esthetics" stands as a lonely sentinel for the profession (Toumey, 1958) until interest in the amenities of forest management (Twiss, 1969; Bury, 1971) developed as a result of public criticism. Forestry education is now admitted to be weak in esthetics, in practice in dealing with a variety of constituencies (Beale, 1970), and deficient in the broad outlook necessary "to achieve empathy, let alone leadership" of the current environmental surge (Duerr, 1972).

Discussion

The analysis of multiple use conflicts on the national forest lands is still foundering on the point discussed by Kelley in 1938; that no common scale exists on which to measure and thus compare benefits from different uses (Kelley, 1938). Unquantifiable parameters such as esthetic values can be introduced to the decision-making or balancing process between incompatible uses as has been done by limiting or restraining the technique of clearcutting. More attention has been given recently to dominant uses in specified areas (Public Land Law Review Commission, 1970) as urged by the timber constituency. The Forest Service supported the National Timber Supply Act of 1969, for instance, which would have greatly emphasized the wood supply functions of

the national forest by increasing the allowable cut through more intensive management, and creating an earmarked high yield timber fund (Cliff, 1969). Whether wilderness should be considered as a stock resource (non-renewable) or as a flow resource as is usual for forests, or whether it is a "dominant use" excluding others (McArdle, 1961; Bronson, 1971) are questions unresolved as yet. K. P. Davis defines multiple use as any combination, limitation, or sequence of uses on a single area, while suggesting that in common usage the term has come to mean "preservation" rather than use management (Davis, 1969). As long as no formal mechanisms for resolving multiple use conflicts exist, it remains inevitable that the faith and value judgments of foresters will be final arbiters of the difficult policy questions posed by multiple use conflicts (Duerr, 1967).

A prime feature of the arguments over sustained yield involves the concept of allowable cut. After charges that allowable cuts violate sustained yield, and USFS counterclaims of a 20-year excess of allowable cut over actual cut, the argument appears to center on how the allowable cut limits are determined and what level of "even-flow sustained yield" is to be chosen. Since western allowable cuts are high now "in order to bring these areas under sustained yield," it would appear that allowable cut and sustained yield are indeed not identical concepts. What role does the desire to maximize growth play in the setting of these quotas? How did it happen that allowable cut changed from an upper limit to a minimum quota target (Stoddard, 1969)? Is it reasonable to use growth in remote areas to "balance" the cut in other areas? Is it proper to count past "growth margins" in calculating future cuts when quality of the forest resource is still declining and quantity is only temporarily increasing?

Perhaps a message of the public concern over uses of the public forests is that the public will soon require a change in the Forest Service's traditional and non-specific role of "steward" to the more demanding and higher order role of fiduciary or public trustee (Curlin, 1972).

Most conspicuous in reviews of the institutional setting of this conflict is the lack of structure or absence of certain institutional arrangements. It is lack of land tenure structures requiring landowner duties, the lack of land-use planning requirements, the absence of procedures to resolve multiple-use conflicts, the absence of organizational structures to promote sustained yield, the absence of an effective constituency to counterbalance commodity demands upon the USFS which is often the significant factor in determining the role which the forest resource plays in meeting human needs.

The existence of a "perception differential" as pervasive and varied as that between the intensive management foresters and some segments of the public goes much deeper than differences in attitudes and perceptions. The near-religious fervor with which the apostles of growth and production berate the disciples of wilderness and esthetic values (and vice versa) bodes ill for calm discussion or quick solutions. When heaven is the prize, the believers are quick to claim special rights for themselves and to urge damnation for heretics. The "indifference to clarity" which exists on both sides concerning definitions of conservation and multiple use is of long standing and is

part of deep underlying conflicts among interest groups (Herfindahl, 1961). It represents a major clash of values among constituencies with differing access to decision-making power in the Forest Service and in other arms of government. It emphasizes the institutional basis for the present allocation of forest benefits. It raises serious policy questions which will be outlined later.

THE ROLE OF TECHNOLOGY

As the old conservation movement of the last century was a response to the implications of science and technology (Hays, 1959), the new environmental consciousness is a further response to the impacts of changing technologies in a more crowded world. The institutions which guide the use of the technologies are often inadequate to the task. They may find themselves being guided by the requirements of the technologies instead, once the judgment is made that certain technologies maximize certain goals.

In the case of the Forest Service, policy concerning optimum use of the forests appears to have been heavily influenced in the late sixties by the requirements of clearcutting technology. Clearcutting was adopted in order to maximize growth and production, two agency goals. Much attention has been given to the mechanization of logging, planting, brush clearing, etc., and the requirements of bigger and more efficient machinery (McConnin, 1967; Boe, 1963). It is probably no accident that the intolerance of new and bigger machinery for residual stands (the result of selection cutting) coincides with the adoption of clearcutting as the Forest Service's preferred policy in 1964. One rationale for increased allowable cuts in the western forests is the belief that technological improvements (lamination techniques, paper overlays) make large trees no longer necessary to supply product needs of the future (Guthrie, 1961). Hence, the allowable cut is increased beyond the sustained yield level to hasten the time when slow-growing "overmature" trees are removed to be replaced by a faster growing new crop (Guthrie, 1961). "Economic maturity" has replaced the concept of "biological maturity." Fragile ecosystems formerly inaccessible are now subject to massive disturbance by large machinery because of new technologies and roads. Steep slopes formerly considered unharvestable are cut because new techniques of terracing and artificial planting make reforestation a possibility.

Inadequate funding and budgetary cutbacks for federal agencies have meant inadequate supervision in the field of the operation of big machinery, admitted as a major weakness in the clearcutting hearings (Cliff, Hearings, p. 848, 1971). In this case the institutional flaw is apparently not adequacy of contract requirements, but implementation of a requirement meant to control a potentially damaging technology.

A significant institutional characteristic revealed in the past decade is the uncritical willingness to use drastic technologies prior to any assessment of their potentially massive impacts. Almost no data exists as to the long-term impacts of clearcutting, a procedure which results in extensive disturbance of soils, water retention patterns, nutrient cycling, energy flow

in the ecosystem, and micro-climate. For instance, comparative data on siltation resulting from different harvesting patterns are lacking though long-term studies are now in progress (Tarrant, 1971). Luma Leopold has noted the lack of studies under "real-life" conditions in the case of hydrologic research (Leopold, 1971). Extensive economic assessments have been made for each new technology adopted, but few assessments of other impacts can be found, with the exception of experiments testing the nature of clearcutting as a regeneration technique (McQuilkin, 1970; Ronco, 1971; Metzger, 1971; McGee, 1970; Minckler, 1971).

One interpretation of the public protest against USFS management is that it is a citizens' technology assessment movement. Because of lack of adequate technology assessment by the professional managers, environmental and conservation groups have attempted to conduct a "technology assessment" of clearcutting and other technologies as in the Clearcutting Hearings.

The development of powerful technologies to attain certain goals can seriously unbalance the relationship with other co-equal goals. Not only has the adoption of clearcutting given a great edge to commodity functions of forest management, but the computerization of decision-making technology within the Forest Service is having the same effect. Computers can deal only with quantified information, and the lack of quantification of amenity values prevents their being considered in computerized multiple-use analyses. The net result of the use of new technologies has been to precipitate the Forest Service into a growing conflict over the relative weight to be given different values in use of the forests, and to complicate the reconciliation of different and incompatible uses.

POLICY QUESTIONS RAISED

The policy question raised by this study will be identified but not analyzed in this interim report. They include:

Problems of Use

How shall we use the public forests?

What needs shall they satisfy? Can these needs be defined well enough to permit analysis?

What options remain in the light of past policy decisions which affect the quality and extent of the total forest resource?

How shall forest products needs be met if increasing proportions are not to come from the public lands?

Problems of Balance

What is the proper balance of the many possible uses of public forests?

Shall economic criteria remain primary?

Should the forests be cast in a new role to satisfy cultural, esthetic, and amenity values primarily?

What is the proper weight to give to wilderness use, that "most complete expression of amenity concerns"? (Davis, 1969)

Is dominant use of certain areas a feasible alternative?

Shall multiple use be sequential, simultaneous, adjacent?

What balance of present and estimated future need should be struck? For instance, can we estimate the future need for wood as well as future need for wilderness?

Problems of Regulation

How should the use of private forest resources be coordinated with the public forest resource?

Shall we continue the subsidy of private forest lands without regulation?

Should the public interest in private forests take more specific form in some type of regulation of private practices?

What regulations of private and public land use should be taken to protect the integrity of productive lands such as forests? (if any?)

Problems of Who Decides

What role shall the public play in decision-making beyond the present situation?

Shall allocation of resources remain the province of the technical elite, the foresters?

How shall the boundaries between technical expertise and value judgments be identified?

What formal public rights should be promulgated, if any, and where in the decision-making process should these rights be inserted?

Through what mechanisms should the public exercise these rights?

Problems of Institutional Arrangements

What institutional arrangements are needed to accomplish existing and possible future policy decisions?

Are present arrangements adequate in fostering sustained yield, multiple use, reforestation?

If not, what alterations to tax, inheritance, insurance, and credit laws would be reasonable and feasible?

What changes are needed to encourage ecosystem management?

POSSIBLE RESOLUTIONS OF THE CONFLICT

Possible resolutions to the conflict over forest management and land use will be discussed in the final paper under the following general categories:

- 1) Research needed to provide basic data for decision-making.
 - a. clearcutting effects
 - b. quantifying amenity concerns
 - c. identification of "use limits" for various ecosystems
- 2) Ecosystem management as a management objective.
- 3) Reducing demand for virgin wood material.
 - a. recycling
 - b. utilization increases
- 4) Increasing supply of timber and forested area.
 - a. reforestation
 - b. institutional innovations to increase commodity and amenity values on non-industrial private woodlands.
- 5) Institutional arrangements to permit sustained yield and multiple use management on all types of ownerships.
 - a. bringing amenity values into market allocation system
 - b. tax and credit law changes
- 6) Comprehensive land use regulation.
- 7) Public participation mechanisms for decision-making.

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UTILIZATION OF FOREST PRODUCTS RESIDUES

by

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Today's forest products residues will undoubtedly be a significant part of tomorrow's raw material resources. There have been extensive gains in the utilization of formerly wasted slabs and edgings from lumber production, veneer cores from plywood production, and sawdust from manufacturing operations during the last few decades, and the trends as established are continuing. The main deterrent to more rapid elimination of apparent wastage is economics.

By definition, forest products residues are wood materials from logging and manufacturing not used for some product such as fuel or pulp. Costs of processing and transportation prevent more intensive utilization now; however, research, increasing demands for forest products, adverse reactions to environmental impacts and proposals for subsidization are changing the overall picture.

Residues may logically be separated into logging residues, primary manufacturing residues, and secondary manufacturing plant residues. According to Lassen and Hair¹, the total volume of residues in 1968 amounted at 4.4 billion cubic feet--about a third of the volume of timber harvested.

Logging residues including portions of tree trunks, limbs, and rough and rotten trees 4 inches or larger in diameter left on the ground accounted for 45 percent of the total volume. Primary manufacturing residues mainly from sawmills, veneer mills, and pulp mills accounted for 39 percent. Most of the remainder is generated at such secondary manufacturing plants as millwork plants, dimension and flooring mills, and container, pallet, and furniture plants.

Besides these major residues, an additional 0.4 billion cubic feet of unused bark were accumulated at primary plants in 1968. In many cases bark presents a separate and different problem from other types of wood wastes. Commonly, economics are favorable for chipping bark-free wood for use in paper or particleboard production. Bark in admixture with wood chips is a contaminant in paper production and not more than about 3 percent bark can be tolerated

¹Potential Gains in Wood Supplies Through Improved Technology, Journal of Forestry, Vol. 68, No. 7, July 1970.

unless costly refining processes are employed. Bark mixed with wood chips for particleboard manufacture causes reduction of strength in the end product.

Accumulations of logging residues in the wood are called slash. Such residues may be ecologically beneficial or harmful. Rotten logs may provide shade needed for seedlings to become established. Slash may protect young trees from deer browsing and soil erosion. However, slash can also have such harmful effects as encouraging insect and rodent populations to increase rapidly, inhibiting regeneration, hindering human access, and creating hazardous fire conditions.

Residues generated at primary and secondary manufacturing plants create serious disposal problems. Disposal by incineration may produce harmful environmental impacts with typical types of previously used burners or become too costly with improved burning processes. Disposal by landfilling is also an expensive operation.

To solve the problems associated with residues, available practices and knowledge which encourage more intensive utilization must be employed. Research and Development directed toward residue utilization will continue to provide needed knowledge to make more complete use of felled timber economically possible.

Use of residues for production of energy is a promising field for additional investigation. At this time wood fired boilers for low-pressure steam production are available and some are being used. The units are characterized by relatively high initial cost and low operating cost, exactly the reverse of oil or gas-fired installations. In view of restrictions on construction of other kinds of new power plants, construction of steam power generators based on wood as a fuel appears more advantageous.

One advantage of burning wood residues rather than fossil fuels is that bark and wood residues contain essentially no sulfur. On the other hand, coal, depending on the source, contains 1 to 3 percent sulfur. Wood residues are more bulky than coal, and studies at TVA have determined that it takes about two pounds of bark to produce as much energy as one pound of coal.

Dr. George Szego, consultant to the National Science Foundation on the U.S. energy problem, has proposed that the United States deficiency in energy production in the near future be satisfied by harnessing solar energy and he feels that photosynthesis through forest trees is the best means for accumulating and storing solar energy. Other studies on the utilization of wood residues for fuel have indicated that bark is a cheaper source of power than gas in the Intermountain area and sophisticated combustion processes might be used to convert municipal waste and wood residues into power in municipalities in wood producing areas.

The Bureau of Mines has studied two processes for converting cellulosic wastes to fuel. One is a pyrolysis method in which the waste is heated in a closed system at atmospheric pressure without the addition of air or other gas. In the second method, waste is heated under pressure in the presence of carbon monoxide, steam and a catalyst also in a closed system. This is a hydrogenation

process since the waste is treated with hydrogen produced by reacting carbon monoxide and steam.

Although burning of wood residues for fuel may be the best means for ultimate disposal of unwanted wood fiber accumulations, there are good possibilities for utilizing more of the wood fiber products and reducing waste now. For instance, work at the Forest Products Laboratory in Madison, Wisconsin, has shown that incorporation of an improved sawing process in saw-mills could increase the recovery of lumber products from small logs by 10 percent. Research at the Forest Products Laboratory and at the extension of the Southeastern Forest and Range Experiment Station at Athens, Georgia, is producing knowledge aimed at more efficient use of wood in housing construction. Ultimately, better processes for the production of wood products together with advanced engineering techniques for application of wood products in construction could result in the production of twice as many wood buildings from the supply of standing timber in the forest.

One very promising avenue for increasing product yield from the tree and reducing residues lies in the development of an economical process for the production of structural particleboard from low-value material provided the low-value material can be recovered economically from the forest.

One approach to the problem of recovering wood fiber material from the woods more readily is to chip tops, limbs, and low-grade logs in the woods and to economically transport the chips to a point of remanufacture, possibly through such an advanced transportation system as a wood-chip pipeline.

However, there are additional problems in converting wood chips into a structural particleboard product. Unless the particleboard has significantly higher strength than the conventional board used for such purposes as counter-top core material and floor underlayment, production cost precludes competition with conventional boards products from plant manufacturing residues. Strength could be added to the board by addition of a greater amount of resin binder but this is a costly process. Another more promising approach would be to produce long flakes instead of conventional chips for board production. If chips could be produced in chunks the size of a finger instead of the conventional small sizes, they could be processed through flaking machines and be manufactured readily into strong boards. The secret of producing a strong structural particleboard is in having flakes that are two to three inches long.

Another means for improving a bulk chip product, such as tops and limbs, which is not conveniently debarked prior to chipping, is in the separation and segregation of bark from wood chips. Research at the North Central Experiment Station of the Forest Service has resulted in a process which can be used to satisfactorily separate the bark from the wood chips of Lake States pulp species. Plans are underway to build a pilot operation using this process in conjunction with a pulping and paper making operation soon.

Other existing and potential uses for wood and bark residues include mulches and soil amendments for horticultural purposes, poultry litter and animal bedding, charcoal briquettes, compressed fireplace logs, reduction agents

in metallurgy, extenders for plastics, additives in oil well drilling needs, and animal feed.

Biological degradation of wood and bark forms humus which imparts desirable properties to the soil. Because of this, bark is commonly used as a soil amendment or conditioner. However, horticultural markets could consume much larger quantities of such products eventually. Products may be improved by such processes as hammermilling, shredding, pelletizing, composting, and supplementing with nutrients. The Forest Service now has research underway at the Rocky Mountain Forest and Range Experiment Station to mix wood residues with sewage sludge to produce a better soil additive through the combination of two waste products.

The Forest Service, in cooperation with the Agricultural Research Service and State Forest Experiment Stations, has successfully demonstrated the use of sawdust and wood residues for animal feeding. Some types of sawdust were as effective as hay for a supplementary bulk feed and sawdust from some species such as aspen had nutritive value.

Reuse and recycling of wood or cellulosic fiber also aids in conserving the forest resource and is allied with residue utilization in extending the timber supply. About 18 to 20 percent of our paper production in the United States is recycled annually. Most of this is from newspapers which have been separated from other types of household and commercial waste. The Forest Service, together with the Bureau of Mines and the Environmental Protection Agency, is involved in research which permits separation of wood fiber wastes from other municipal trash such as glass and metals, and subsequent recycling of the cellulosic material. The wood fiber can be reprocessed into various grades of paper and perhaps even more significantly, into wood fiber board products. Such products are used in building construction and remain in place for comparatively long periods of time. This extends the time interval between subsequent recycling of the wood fiber product. On the other hand, paper is a relatively short-lived product, and could be recycled a number of times within a relatively short time span. Since wood fibers are reduced in length and degraded in each recycling, it is advantageous to extend the time between recyclings. Although greater recycling of wood products is desirable, total recycling as has been advocated for other materials is less critical since forest products are renewable. Other advantages of forest raw materials for various applications include biodegradability and the fact that they can be transformed with finished products with comparatively little expenditure of energy.

The large volumes of logging and wood manufacturing residues, urban waste, and wooden debris which are generated in the United States annually constitute a potential resource. It has been estimated that in the near future, intensified harvesting and forest products utilization research could make it technically and economically feasible to gain the equivalent of 4.7 billion cubic feet of wood from the potential residue resource. Achievement of this potential is the challenge.

WORLD IMPORT FUNCTIONS FOR THE PAPER INDUSTRY

by

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INTRODUCTION

The purpose of this paper is to forecast world import demand of paper products with ranking of import markets by dollar value and growth, and the degree of international competition. In doing so, it is hoped that it may contribute useful inputs into a national materials policy on forest products, and assist corporate planning on capacity requirements for a dynamic world market of paper products. A study on the paper industry is of special importance to the Southeast and the State of Georgia due to its leading role in the regional economic development.

METHODOLOGY

The research methodology used in this paper to analyze and forecast imports of paper products is based on an import equation, which is derived from the OECD model¹, the UN methodology², and the writings of eminent scholars³.

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¹ $X_j = a_0 + a_1Y_j + a_2IP_j + a_3DUM_j$ where X_j = value of commodity import of country j ; Y_j = per capita income; IP_j = industrial production index; and DUM_j = appropriate dummy variable to allow for devaluations, policy changes, etc. See Adams, G. F., H. Eguchi and F. Meyer-zu-Schloctern, An Econometric Analysis of International Trade: An Interrelated Explanation of Imports and Exports of OECD Countries. Paris, 1969.

²UNCTAD/GATT, Manual on the Compilation of Basic Information on Export Markets, Geneva, 1968.

³See articles on econometric analysis of international trade by Bert G. Hickman, Lawrence R. Klein, and Rudolf R. Rhomberg, and F. Gerald Adams and Helen B. Junz in International Business Systems in Perspective, edited by C. G. Alexandrides in 1972.

The limitations of the study are of terminological and model-building nature. The term world imports refers to the ten most important import markets, which constitute about four-fifths of world imports. Due to space limitations only the first two exporters are given, which in most cases constitute the bulk of shipments into the importing country. The twelve paper products analyzed in the tables include all paper group commodities for which import data are reported to the UN Statistical Office.

The forecast of imports of paper products in world markets are made on the following assumptions for the 1971-1975 period: (1) no trade war will erupt among the ten trading nations, (2) the expanding membership of the Common Market will not integrate the pulp and paper industries to a significant degree during this period, (3) no drastic international monetary realignment of currency, (4) no major technological breakthrough in the paper or related industries will become operational during this period, (5) new producers will not substantially affect the supply and price of paper products, i.e., USSR, and (6) ecology requirements will not adversely affect paper products and benefit substitute products.

BACKGROUND

The correlation between production and consumption of pulp and paper with main economic indicators can be demonstrated by an analysis of the paper market in 1970 in the major economic areas⁴.

In 1970 the slowdown in economic growth in North America and many European countries either brought the expansion in production and consumption of pulp and paper to an end (U.S., Canada) or considerably reduced it (OECD Europe). The only exception was economically viable Japan, which expanded at spectacular rates its production of paper and board in sharp contrast to other OECD countries.

In the U.S. the demand for paper and board was critically affected by the recession, which prevailed through 1970, and fell by 2.3% (at 1,155,000 metric tons) in 1970 as compared with 1969.

In Canada 1970 was a very difficult year for the pulp and paper industry as a result of the decline in North America's economic growth and a number of prolonged strikes. Production leveled out and deliveries dropped by about 1% in Canada in 1970. This decline was largely due to the drop in Canadian exports to the U.S., which is Canada's main market.

In Europe economic growth which was sustained in 1969 and the first half of 1970, suddenly declined during and after the autumn of 1970. As a result of the general sluggish economic conditions, the demand for paper and board declined and the average rate of increase in European consumption was less than anticipated.

⁴For a detailed analysis, see The Pulp and Paper Industry 1970-1971, OECD, Paris, 1971.

Japan became in 1970 the second producer of paper and board, and third world producer of woodpulp. Production of paper and board in Japan expanded at a rate of 15% in 1970, which outstripped the records for its previous two years.

The economic recovery beginning in late 1971 is expected to increase production of pulp and paper with an appropriate time lag to account for particular production problems in this industry and the dock strikes.

FORECASTING WORLD IMPORT DEMAND FOR PAPER PRODUCTS

Future trends in import demand for paper products in the major industrialized nations will be definitely up according to our projections⁵. The overall growth in world imports of paper products is estimated to increase by an annual average rate of 12% in the 1971-1975 period. The most significant importers of paper products in order of importance are the following: the U.S., West Germany, United Kingdom, France, the Netherlands, Belgium-Luxembourg, Denmark, Italy, Canada and Switzerland. These countries are demanding paper products in the form of paper, paperboard, and manufacturers of same, ranging from standard newsprint paper to wallpaper and from paper bags to cigarette paper at unprecedented rates. The major exporters of these paper products, supplying nearly three-fourths of world demand, are in order of importance as follows: Canada, Finland, Sweden, West Germany, and the U.S.

The U.S. share of world markets for paper products was 8.8% in 1969 and is expected to increase slightly in the next five years at the expense of the Canadian market share, which amounted to 35% in 1969. The market shares of Finland and Sweden are expected to also increase slightly.

The U.S. imports nearly one-third of the paper goods from all the countries of the world, which totaled \$1.039 billion in 1969. The U.S. exported \$280 million in 1969, which makes the U.S. a net importer of paper products to the tune of over three-quarters of a billion dollars. Ninety-two percent of U.S. imports come from Canada.

For a detailed import demand analysis of 12 paper products in the major markets of the world consult the following tables:

⁵ Projections were made by the international market information system at Georgia State University on the basis of the import equation described in the research methodology.

NEWSPRINT-PAPER-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	U.S.	6200.0	+	CANADA	5952.0	96.0	=	FINLAND	242.0	3.9	=
2	GERMANY	642.9	+	FINLAND	193.5	30.1	-	SWEDEN	163.8	25.5	-
3	UK	597.4	+	CANADA	330.5	55.3	-	FINLAND	175.8	29.4	+
4	NETHERLA	156.0	+	FINLAND	65.0	41.6	=	SWEDEN	39.3	25.2	=
5	FRANCE	138.4	+	SWEDEN	44.7	32.3	-	FINLAND	44.4	32.1	=
6	JAPAN	123.9	+	CANADA	111.6	90.0	+	USSR	11.0	8.9	=
7	BELG-LUX	97.5	+	NETHERLA	28.7	29.5	-	FINLAND	22.2	22.8	-
8	SWITZERL	20.6	+	SWEDEN	7.9	38.1	-	AUSTRIA	2.7	13.1	=
	TOTAL	7976.7									

OTHER PRINTING & WRITING PAPER-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	GERMANY	839.4	+	FINLAND	165.0	19.7	=	NETHERLA	139.7	16.6	=
2	U.S.	490.0	+	CANADA	411.0	84.0	=	FINLAND	48.0	9.8	
3	UK	430.4	+	FINLAND	166.3	38.6	-	SWEDEN	96.8	22.5	=
4	FRANCE	343.0	+	GERMANY	94.2	27.5	=	FINLAND	41.8	12.2	=
5	BELG-LUX	330.7	+	NETHERLA	101.9	30.8	-	FRANCE	78.9	23.9	=
6	NETHERLA	308.9	+	GERMANY	107.6	34.8	+	FINLAND	33.8	11.0	=
7	SWITZERL	155.0	+	AUSTRIA	49.0	31.6	=	SWEDEN	39.8	25.7	=
8	SWEDEN	37.0	+	GERMANY	21.6	58.2	=	DENMARK	5.3	14.3	=
9	ITALY	34.0	+	GERMANY	9.2	27.1	+	FRANCE	8.1	24.0	+
10	JAPAN	5.3	+	U.S.	1.7	32.3	+	CANADA	1.0	19.4	+
	TOTAL	2973.7									

KRAFT PAPER & PAPERBOARD-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	GERMANY	1173.5	+	SWEDEN	374.7	31.9	-	U.S.	288.6	24.6	=
2	UK	985.6	+	SWEDEN	309.3	31.4	=	U.S.	265.0	26.9	-
3	FRANCE	373.6	+	SWEDEN	172.1	46.1	=	U.S.	74.6	20.0	+
4	ITALY	248.6	+	U.S.	101.4	40.8	+	SWEDEN	61.7	24.8	-
5	NETHERLA	190.1	+	SWEDEN	80.7	42.5	-	FINLAND	52.7	27.7	-
6	BELG-LUX	186.2	+	SWEDEN	80.2	43.1	-	FINLAND	40.9	21.9	-
7	U.S.	60.0	+	CANADA	21.0	35.0	+	SWEDEN	18.0	32.0	-
8	SWITZERL	52.0	+	SWEDEN	23.0	44.3	=	FINLAND	20.1	38.6	=
9	SWEDEN	26.2	+	FINLAND	17.2	65.5	+	U.S.	6.6	25.2	-
	TOTAL	3995.8									

CIGARETTE PAPER-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	BELG-LUX	4.7	+	FRANCE	4.7	99.3	-				
2	SWITZERL	1.6	+	SWEDEN	1.5	92.1	=				
3	ITALY	.9	+	GERMANY	.6	73.5	+				
4	FRANCE	.5	+	GERMANY	.3	73.9	-				
5	U.S.	.4	+	NA							
	TOTAL	.4									

MACHINE-MADE PAPER & PAPERBOARD-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	GERMANY	506.3	+	FINLAND	106.0	20.9	=	SWEDEN	102.3	20.2	=
2	UK	348.8	+	SWEDEN	119.0	34.1	=	FINLAND	89.8	25.8	+
3	FRANCE	191.1	+	FINLAND	50.8	26.6	=	GERMANY	30.2	15.8	+
4	BELG-LUX	144.6	+	NETHERLA	36.5	25.3	=	FINLAND	24.2	16.7	=
5	NETHERLA	118.4	+	GERMANY	22.9	19.3	=	FINLAND	20.1	17.0	=
6	SWITZERLA	92.4	+	FINLAND	21.8	23.6	=	SWEDEN	21.6	23.3	=
7	U.S.	52.0	=	CANADA	16.6	30.0	+	FINLAND	14.0	27.0	-
8	SWEDEN	32.6	+	FINLAND	9.3	28.6	=	GERMANY	6.0	18.5	-
9	JAPAN	12.7	+	U.S.	8.5	66.9	+	GERMANY	2.1	16.6	=
	TOTAL	1499.0									

FIBREBOARDS & BUILDING BOARDS'-PULP OR VEG. FIBRE-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	UK	171.5	+	SWEDEN	76.4	44.6	-	FINLAND	26.9	15.7	=
2	U.S.	164.2	+	CANADA	47.6	29.0	+	SWEDEN	46.0	28.0	-
3	NETHERLA	96.0	+	SWEDEN	39.0	40.7	=	FINLAND	15.9	16.6	=
4	GERMANY	92.5	+	SWEDEN	31.0	33.5	-	FRANCE	15.6	16.9	=
5	BELG-LUX	55.0	+	SWEDEN	11.2	20.4	-	GERMANY	11.1	20.2	=
6	ITALY	18.0	+	AUSTRIA	12.6	70.4	-	FRANCE	2.5	13.6	=
7	SWEDEN	2.3	+	FINLAND	1.1	48.1	+	U.S.	1.0	43.6	-
8	JAPAN	2.0	+	AUSTRALIA	.9	44.8	+	U.S.	.01	2.8	=
	TOTAL	601.6									

HAND MADE PAPERS-IMPORT DEMAND PROJECTIONS 1971-1975

(IN THOUSANDS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	JAPAN	2250.0	+	RED CHINA	2183.0	97.0	+	TAIWAN	38.0	1.7	=
2	UK	444.0	+	JAPAN	338.0	76.0	-				
3	U.S.	400.0	+	NA				NA			
4	SWITZERL	370.0	+	JAPAN	246.0	66.4	+	FRANCE	57.0	15.4	=
5	SWEDEN	31.0	+	GERMANY	18.0	59.1	+	JAPAN	10.0	31.8	=
	TOTAL	4.3									

PAPER & PAPER BOARD IN ROLLS OR SHEETS-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	GERMANY	571.0	+	NETHERLA	117.5	20.6	=	U.S.	62.6	62.6	=
2	FRANCE	496.6	+	GERMANY	139.8	28.1	=	U.S.	50.2	10.1	=
3	UK	460.2	+	FINLAND	118.0	25.6	=	SWEDEN	107.0	23.3	=
4	NETHERLA	276.8	+	GERMANY	81.1	29.3	=	SWEDEN	41.6	15.0	=
5	BELG-LUX	214.0	+	GERMANY	63.5	29.7	=	NETHERLA	57.6	26.9	-
6	ITALY	189.8	+	GERMANY	51.0	26.9	=	UK	26.0	15.0	=
7	SWEDEN	150.3	+	FINLAND	47.7	31.8	+	U.S.	19.7	13.1	=
8	U.S.	141.0	+	CANADA	46.5	33.0	+	GERMANY	24.0	17.0	-
9	SWITZERLA	131.7	+	SWEDEN	38.2	29.0	=	GERMANY	32.1	24.3	-
10	JAPAN	48.6	+	U.S.	19.9	40.9	=	GERMANY	15.7	32.2	+
	TOTAL	2680.0									

PAPER BAGS, PAPER BOARD BOXES & OTHER CONTAINERS-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	COUNTRY NAME	INT IMPORT DEMAND \$	T	FIRST EXPORTER	TOTAL EXPORT \$	%	T	SECOND EXPORTER	TOTAL EXPORT \$	%	T
1	BELG-LUX	149.6	+	NETHERLA	79.9	53.4	-	GERMANY	30.9	20.7	=
2	GERMANY	140.4	+	NETHERLA	66.7	47.5	=	FRANCE	37.8	26.9	-
3	FRANCE	130.7	+	GERMANY	42.8	32.7	=	ITALY	28.5	21.8	=
4	NETHERLA	112.6	+	GERMANY	44.3	39.3	=	UK	7.1	6.3	=
5	U.S.	50.0	+	CANADA	20.5	41.0	=	JAPAN	13.5	27.0	=
6	SWEDEN	42.8	+	NORWAY	16.7	39.1	=	DENMARK	9.0	21.1	+
7	UK	41.3	+	IRELAND	17.2	41.7	=	DENMARK	6.4	15.5	=
8	ITALY	32.1	+	GERMANY	13.6	42.4	-	SWITZERL	8.0	24.9	=
9	SWITZERL	25.6	+	GERMANY	8.0	31.1	-	SWEDEN	3.9	15.1	+
10	JAPAN	11.2	+	U.S.	9.2	81.9	+	UK	.1	.08	=
	TOTAL	736.3									

ENVELOPES, WRITING BLOCKS, ETC.-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

[illegible]

EXERCISE BOOKS, REGISTERS, DIARIES, ETC.-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

	<u>COUNTRY NAME</u>	<u>INT IMPORT DEMAND \$</u>	<u>T</u>	<u>FIRST EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>	<u>SECOND EXPORTER</u>	<u>TOTAL EXPORT \$</u>	<u>%</u>	<u>T</u>
1	U.S.	128.6	+	NA							
2	BELG-LUX	37.3	+	GERMANY	13.4	35.8	=	NETHERLA	11.9	31.9	-
3	FRANCE	36.6	+	GERMANY	12.8	34.9	=	ITALY	10.4	28.5	=
4	NETHERLA	19.6	+	GERMANY	8.6	43.8	=	EAST GERMANY	2.9	14.7	=
5	UK	15.7	+	U.S.	3.4	21.5	=	JAPAN	3.3	20.8	-
6	SWITZERL	13.5	+	GERMANY	7.3	53.6	-	JAPAN	1.3	9.6	=
7	GERMANY	12.7	+	NETHERLA	7.5	58.9	-	FRANCE	1.7	13.1	=
8	SWEDEN	9.4	+	DENMARK	2.4	25.4	=	GERMANY	2.0	21.1	=
9	ITALY	7.8	+	GERMANY	3.3	43.1	-	FRANCE	2.0	26.4	=
10	JAPAN	2.2	+	U.S.	.8	36.3	+	UK	.2	11.3	=
	TOTAL	128.6									

PAPER PULP, PAPER BOARD ARTICLES-IMPORT DEMAND PROJECTIONS 1971-1975

(IN MILLIONS)

[illegible]

CONCLUSION

The dynamic nature of the world market for paper products can be attested by the average annual growth rate of 12% forecasted for 1971-1975. Moreover, the average annual growth rate of U.S. imports of paper products from the world is projected at about the same rate.

As a result of its increasing net paper import condition, the U.S. should adapt appropriate national materials policy in this field. Proper policies should promote the expansion of exports in paper product lines in which the U.S. has growing market shares abroad, i.e., Kraft paper and paperboard, paper pulp and paperboard articles.

POLICY STATEMENT ON DETERIORATION OF ENGINEERING MATERIALS

Prepared by Workshop I
Dr. Roger W. Staehle, Co-Chairman
Ohio State University
and
Dr. John D. Muzzy, Co-Chairman
Georgia Institute of Technology

BACKGROUND

The premature deterioration of engineering materials represents a serious loss of natural resources and a substantial hazard to public safety. Magnitudes of the deterioration and safety considerations are such that nationally coordinated action should be directed toward remedial measures. Discussed herein are:

1. Definition and scope of engineering materials and deterioration phenomena
2. Quantitative magnitude of losses from deterioration
3. Extent and type of safety hazards
4. Recommended action for assessments of the deterioration of catastrophic failure problems
5. Recommended action in area of education
6. Recommended action in area of research
7. Implication and relationship of corrosion to recycling processes

The deterioration of engineering materials warranted study by this committee because:

1. The annual estimated direct cost of corrosion of metals is $\$15 \times 10^9$ per year in the U.S.; of this cost the recoverable loss is estimated to be $\$5 \times 10^9$. The term "recoverable" implies that the loss could be prevented if existing technology were applied. The annual cost of deterioration of all engineering materials is certainly much greater but detailed assessments have never been conducted.

2. The lifetime of highway surface materials and bridge structures is being severely reduced where there is extensive use of rock salt for de-icing surfaces. Reliable estimates for the northeastern U.S. show that the lifetime of road surfaces in some cases is about seven years rather than the design life of 20 years; in the same rock salt environment bridge decks deteriorate sometimes in a single year.

3. Catastrophic failures of engineering solids in equipment have cost millions of dollars, and the unavailability of crucial military hardware.

4. The productivity of most polymer fabrication operations is limited by thermal degradation.

Definition and Scope of Engineering Materials and Deterioration Phenomena

We define engineering materials as the complete set of those materials used to build the machines, appliances, structures, and other objects of use to society. We consider that engineering materials should include the following:

1. Metals
2. Polymers
3. Glasses
4. Ionic solids
5. Aggregates
6. Rock
7. Natural fibers such as wood
8. Earth (including clay)
9. Bitumens
10. Composite materials

Deterioration phenomena include a broad range of environmental interactions. These include, for example, the following:

1. Aqueous, atmospheric, and high temperature degradation processes
2. Deterioration of highways and bridges produced by road salt
3. Acid rain accelerated attack of exterior structures
4. Sunlight embrittlement of polymers in exterior applications
5. Ozone cracking of rubber
6. Wear of moving parts
7. Fatigue and brittle fracture resulting from excessive stress fields
8. Deterioration of the reliability of electronic equipment resulting, for example, from spurious short circuits induced by electro-transport
9. Bacteriologically induced degradation of aircraft fuel tanks and dry rot of wood
10. Failure of protective coatings and adhesives by hydrolysis
11. Combustion of organic materials.

Quantitative Magnitude of Losses from Deterioration

Estimates of the national (USA) losses due to corrosion of metallic materials were first prepared in 1950 by Professor Uhlig of M.I.T. The extrapolation of his estimates to today's prices suggests a 15 billion dollar annual loss due to corrosion. A recent study by Battelle Memorial Institute has shown an increase in corrosion due only to noxious atmospheric pollutants cause $\$1 \times 10^9$ in recoverable damage.

Recently, the United Kingdom has conducted a detailed industrial study

of corrosion costs using a panel of 20 experts. They made 813 industry contacts as well as interviews or contacts with 13 learned societies, 21 consultants, 22 protection firms, 57 universities, 403 technical colleges, 59 research associations, 15 non-service government departments, and 67 defense establishments. They concluded the following: "We conservatively estimate the cost of corrosion as 1.365×10^9 ($\$3.4 \times 10^9$) per annum which represents 3.5 percent of the gross national product. We believe that a saving of 3.10×10^9 ($\$7.4 \times 10^8$) could be achieved with better use of current knowledge and techniques." A similar U.K. study showed a $\$1.5 \times 10^9$ of recoverable loss due to destructive wear phenomena.

Extrapolating the U.K. figures for corrosion and wear of metals to the U.S. cannot be done with any precision. However, we consider it to be a conservative estimate to suggest that $\$7.5 \times 10^9$ dollars per year could be recovered in the U. S. from present losses due to corrosion and wear of metals. The total cost of corrosion and wear of metals alone in the U. S. would be on the order of $\$2 \times 10^{10}$. This also corresponds with the corrected value of Professor Uhlig's prediction when converted to present prices.

The estimate of total recoverable costs for all engineering materials cannot be made at this time without obviously questionable assumptions, since no definitive studies are available. Nonetheless, the final result after a serious deliberation would actually be expected to produce a figure several times that for metals alone for recoverable costs.

Extent and Type of Safety Hazards

Catastrophic materials failures costing life and generally jeopardizing public safety have never been quantitatively reviewed nor assessed either in the U. S. or other countries. Examples of such catastrophic failures include:

1. Pipelines carrying natural gas have exploded and the fractures run several miles before arresting. The 1965 pipeline accident at Natchitoches, Louisiana killed 17 people.

2. Bridges fail, as for the case of the Silver Bridge across the Ohio River at Point Pleasant, West Virginia where 46 persons were killed. This failure was caused by mechanical-environmental interactions.

3. In the human body metal and plastic devices fail, including pacemakers and metal and plastic implants for bone repair.

4. In the United Kingdom the Comet jet liners and in the U. S. the Electras failed for reasons of fatigue.

5. In the U. S., as well as in the countries of our allies and various enemies, military equipment has been inoperative as much due to materials defects as to military usage. Condenser failures in the United Kingdom during World War I, stress corrosion of German submarine hulls in World War II, and

stress corrosion of missiles and aircraft components during the past years in the U. S. are appropriate examples.

6. From 1942 to 1952 approximately 250 ships experienced fractures that weakened the main hull structure so that the vessels were lost or in a dangerous condition; 19 of these ships broke completely in two or were abandoned after severe cracking.

7. Failure of dams has contributed extensively to loss of life. The Malpasset concrete dam-shaped dam near the French Riviera failed in 1959 killing 421 people. This dam was constructed using best techniques available but the engineers had overlooked the significance of a thin clay seam which nucleated the instability.

While lacking even an approximately quantitative estimate of the magnitude of the catastrophic failure problem, it is instructive to note that most consultants in failure suggest that a majority of all failures could be prevented using information already available with no additional research required. The associated cost of the catastrophe, as well as human lives lost may be then recoverable.

Recommended Action for the Assessment of Deterioration and Catastrophic Failure

We recommend that the deterioration and catastrophic failure of engineering materials be assessed in quantitative detail. Further, this assessment should evaluate whether remedial action requires educational and/or research activities.

We consider that such an assessment is an urgent necessity and should be undertaken at the earliest possible time.

Recommended Action in the Area of Education

The enormous yearly "recoverable" losses due to corrosion of metals provides a substantial and compelling incentive to undertake effective educational activities in the area of materials deterioration.

We recommend that a long term nationally coordinated and substantially funded effort be undertaken to educate the technological community in the ways of reducing destructive deterioration of materials. For example, a substantial educational effort is required to replace existing engineering and construction codes which specify particular materials with performance codes. The constituency of those to be educated include management, practicing engineers, technicians, scientists, college students, and users of the materials.

The media for these ventures include a broad range. Examples are: information centers, movies, packaged courses, short courses, monographs.

The present national approach to education in this area is incredibly fragmented. A cohesive national policy including technical societies, federally supervised research, and industrial efforts is needed.

Recommended Action in the Area of Research

We consider that the present national effort should be supplemented in order to decrease the deterioration and catastrophic failure of engineering materials.

Components of such a research activity would include the following:

1. Analysis of complex systems wherein corrosion and economics involve trade-offs. An example here involves the use of rock salt on highways; both the automobiles and the road surfaces are degraded prematurely, but rock salt is the cheapest of the deicers.
2. Systematic determination of properties of solids and environments relative to propensities to undergo deterioration.
3. Improved and new methods for prevention of premature deterioration.
4. Long term studies to predict behavior of complex chemical-mechanical degradation phenomena.
5. Development of improved performance tests.

Implications and Relationship of Corrosion to Recycling Processes

Many of the processes of interest in deterioration can be utilized constructively in recycling of solids. These include, for example, electrochemical techniques in both aqueous and fused salts, controlled pyrolysis of selected polymer waste to produce useful products such as graphite fibers and activated carbon, and systematic reuse of materials in less demanding applications.

The constructive use of deterioration processes in recycling and materials conversion needs detailed exploration.

POLICY STATEMENT ON TRANSPORTATION AND CONSTRUCTION MATERIALS

Prepared by Workshop II
Dr. William D. Mazanti, Chairman
Georgia Institute of Technology

GENERAL

This statement concerns itself with those materials utilized in the construction industry in structures, road-beds, pavements and other transportation related items.

Basically, these materials are:

- a. Mineral aggregates
- b. Bitumen (asphalt)
- c. Portland cement
- d. Metals.

This statement is based on information which relates the estimated supply and demand of the above named materials up to the year 2000.

Construction materials are largely a non-renewable resource that is vital to sustaining and improving the present economic, social, and political transportation/construction position of the country. A continuing supply of these materials, as well as the identification and development of new materials should be assured in order to meet the needs of the public. This goal should be attained by means which are consistent with the concept of a free enterprise system and with the preservation and enhancement of the environmental quality.

RESOURCE ALLOCATION

There has been a continuous increase in the use of these materials to such an extent that shortages have developed in various parts of the country. Actually, these "shortages" are due primarily to distribution problems since there is generally a plentiful supply, although localized in certain areas of the country.

In many cases, the "shortages" have to do with a lack of specific materials for which there are substitutes within the same general category of materials. The substitutes may be either of slightly inferior quality or somewhat more expensive but in both cases, perfectly capable of providing a structure with satisfactory performance characteristics.

This panel, therefore, accepted as a basis for discussion, the premise that there is a country-wide sufficiency of the materials in question, and attention was focused on other aspects.

In connection with availability of materials, it is recommended that policy be established to develop and to maintain current, an inventory of the location, quality, and quantity of non-metallic mineral resources used in the construction industry. It is further recommended that policy be established which identify these inventories as the basis for long-range planning in order to equitably conserve sources of construction materials in urban areas and other cultural extensions. Inherent in these plans must be the forecasting of needs and the protection of the public interest in meeting these needs.

EDUCATION

The resources of the Federal government, through the Department of Interior, should be brought to bear in promoting research and educational programs which will provide optimum utilization of our natural mineral resources in order to meet present and future construction needs. It is recommended that the educational aspect include the following:

a. Public Education--the public should, through elementary and secondary schools and continuing education programs, be made aware of the importance and limitation in the supply of mineral resources and their proper use for the benefit of public welfare.

b. Higher Education--programs in the physical and social sciences, related to research and utilization of construction materials should be identified and supported in order to develop new technology and better application of existing technology.

c. Manpower Training--programs should be identified and supported which will assure the satisfaction of manpower needs of industry and government in carrying out their activities related to development and use of construction materials.

ENVIRONMENTAL AND LAND USE CONSIDERATIONS

Environmental problems have plagued the transportation and construction industries in increasing proportions in recent years despite the fact that these industries recognize these problems and are putting forth diligent efforts to eliminate or reduce the causes of detrimental environmental disturbances (e.g., noise, air and water pollution, esthetics, etc.).

The major problem areas include water pollution, silt, and sediment control, air pollution (dust or noxious fumes), land disturbance (strip mining), wildlife preservation, and general unsightliness. The problems are

compounded because of the favorable economic position that occurs by locating material-producing industries as close as possible to the consumers, which may be in the areas of high, population-density.

National policy should be developed in the area of long-range planning for optimal systematic land utilization and facility design which will impose minimal adverse environmental disturbance.

A land-use policy is needed to assure the availability of construction materials that are extracted from the ground and the reclamation of the land once the mineral has been depleted. An important element in managing natural resources that are largely owned in the private sector is in the area of depletion allowance and therefore, a sound policy in this regard is necessary.

There is need for an export-import policy which is flexible and sufficiently sensitive to the supply and demand requirements of the construction industry.

ENERGY CONSERVATION

Although the supply of raw materials is, in general, sufficient for the time frame under consideration, there is a distinct possibility of an energy crisis within the same period. As a consequence, national policy should promote as a high priority item, the optimization of material's use with high regard for the conservation of energy as well as of materials resources. This requires material's use decisions which are based not only on cost but on a total-energy-consumption related index as well.

This concept of energy and materials conservation will require research on the quantification of energy expenditure during extraction, processing and manufacturing, and transportation of the various materials. Additional research would be of benefit in the area of more efficient transportation of bulk materials over large distances.

POLICY STATEMENT ON SYNTHETIC AND NATURAL TEXTILES

Prepared by Workshop III
Dr. Winston C. Boteler, Chairman
Georgia Institute of Technology

Present State of the U. S. Textile Industry

In 1971, more than 961,000 people were employed in the textile mill products industry. Another 1.36 million people were employed in the apparel and related industries. Thus one employee out of every eight employees in all manufacturing industries was working in the textile or apparel industries. The textile and apparel industries employ more people in the southeastern part of the U. S. than any other industry, accounting for 43% of all manufacturing employment in Georgia and North Carolina, and about 57% in South Carolina.

Most of the textile and apparel plants are in small towns or rural areas where increased opportunities are needed to prevent the migration of workers to cities and urban areas. Some of the difficulties may be seen upon examination of some textile statistics for 1971. The 1971 foreign trade deficit in textiles was 2.08 billion dollars, with imported textiles representing 13.7% of total U. S. production. While the wholesale price index for all industrial commodities rose to 114.0 in 1971, the price index for textile products, excluding bast and hard fibers, rose only 103.6. The weekly gross earnings for all manufacturing employees in 1971 were \$147.36, while the textile millworkers made only \$104.27. The average weekly gross earnings in the apparel and related industries were \$88.57.

The dissatisfaction of the textile mill worker was emphasized by the labor turnover rates for 1971. The rate for textile employees quitting was 3.4 per 100 employees, compared to 1.8 for all manufacturing industries. While 19% of U. S. textile machinery is exported, the U. S. portion of the world export market during 1970 was only 9.3%, with West Germany, Switzerland, and Great Britain accounting for 59% of world textile machinery exports. Of the 19 types of open end spinning machines being marketed in July 1971, not one was developed or manufactured in the United States.

The Effect of Textile Imports on the U. S. Textile Industry

The U. S. textile industry has had a problem with unrestricted imports which has been responsible for a significant part of the U. S. deficit in the balance of payments. This amounted to more than 2 billion dollars in 1971. Moreover, the concentration of imports on certain fabric styles and apparel items has caused considerable hardship to segments of the fabric and apparel industries.

Bi-lateral agreements have been concluded with five far eastern countries with some encouraging results to date. There are indications that the problem is shifting from agreement countries to non-agreement countries whose geography or state of economic development allows them to respond quickly to opportunities to increase exports to the U. S.

Near term action is needed and required to limit imports from such countries under provisions of present bi-lateral agreements. For the longer term, the only satisfactory solution to this problem is believed to be a multi-fiber, multi-nation agreement similar to the long term cotton agreement.

Cooperative Industry and Government Research and Development Centers

The ultimate long term solution to the textile dilemma along with reasonable sharing of the U. S. market between domestic producers and importers, is to make the U. S. textile industry competitive with other nations' industries. The U. S. textile complex is diverse and divided into a few thousand organizations of varying size. Therefore, a cooperative program involving industry and government is necessary to improve the competitive position of the U. S. textiles.

The first requirement is a commitment by government and industry to develop and maintain in the U. S. a vigorous, innovative, hard working, prosperous textile industrial complex which will be able to compete in the world market and will be adequate to satisfy the nation's needs in times of mobilized maximum effort.

To accomplish this purpose, industry and government should cooperate in applied research, development, education, and dissemination of information in engineering, scientific, and technical areas directed to increasing the productivity and quality of textiles. To accomplish this, two or three centers of research and development, teaching, and communications in textiles should be established at and in conjunction with colleges and universities which maintain vigorous teaching and research programs in the engineering and science of textiles and fibers. These teaching, research and development, and information centers should be supported cooperatively by the state and federal governments, industry, and foundations.

About half the research and development funds should support applied research and development in the centers. The other half should be allocated in grants and contracts by the centers to colleges and universities, private corporations, government agencies, and other groups for specific research and development problems. Research and development should be devoted to specific, identifiable, attainable needs in equipment, methods, and materials to improve the competitive position of the U. S. textile industrial complex. The centers should assist contributors with technical problems of merit and should serve as centers of communication and education to make available quickly to industry the latest innovations in methods and materials.

POLICY STATEMENT ON FORESTRY AND FOREST PRODUCTS

Prepared by Workshop IV
Dr. Nelson K. Rogers, Chairman
Georgia Institute of Technology
Atlanta, Georgia

The work of the committee organized itself into seven areas of major concern.

- I. Enhancing the Productivity of Small Forest Tracts Owned and Developed by Independent Private Landholders.
- II. Provision for Multipurpose Utilization of Forest Lands or Provision for "Casual" Amenity Lands in Areas of Restricted Single Purpose Forests Areas.
- III. Increased Utilization of Residues from Forests and Forest Product Industries.
- IV. Enhancing the Potential for Recycling of Forest Product Materials.
- V. Development of New Products from Forest Raw Materials, Particularly in Regard to Replacement Products for Existing Markets Now Served by Non-Biodegradable Raw Materials and Materials Non-Renewable in Nature.
- VI. Education of the Public Concerning Its Relationships with the Forest and the Products Derived Therefrom.
- VII. Education of the Labor Force Necessary for More Productive Systems in Forestry and in Forest Product Industries.

This list may be further reduced to four primary areas of interest:

The Forest Lands
Forest Materials and Their By-Products
Forest Products
Education of the Landholder, the Manufacturer and the Consuming Public

Changes of attitudes and changes of goals in each of these four areas of interest, over time, will demand changes of policy in each of the seven areas of major concern. It is hoped that the following recommended policies for national consideration are properly responsive to the attitudes and goals of the future in forestry and forest product industries. No degree of relative

importance should be attached at this time to the order in which these policy recommendations are made.

I. ENHANCING THE PRODUCTIVITY OF SMALL FOREST TRACTS OWNED
AND DEVELOPED BY INDEPENDENT PRIVATE LANDHOLDERS

In many sections of our nation, over 50% of our forest materials are produced on small forest tracts by independent private landholders. The committee sees no way in the next 25 years to meet the forest raw material requirements of the nation without enhancing the productivity of such land. The following policies are, therefore, recommended.

1. A national policy of property taxation based on actual land use rather than potential land use must be implemented. If existing independent forest tracts are to be preserved, even though their present productivity levels may be marginal, then they must not be taxed out of existence at a potential commercial property tax rate.

2. A national policy, in regards to inheritance tax treatment of the forest lands, must be developed. Improved productivity in forestry requires long range planning and commitment. Enforced sale of forest lands to developers of other land usage to meet conventional inheritance tax requirements precludes such land, particularly in small tracts, from being anything except a marketable commodity.

3. Federal intervention to insure national uniformity in response to all state forest taxation policies is highly desirable. The importance of sustaining yield must be more clearly delineated.

4. A national policy should be developed for consolidation of small forest tracts into more manageable and controllable large operational entities. This policy should not impinge upon private ownership, but should stimulate the desirability for the independent private landholder to participate in a cooperative effort to increase his land's productivity through economies of scale.

5. National policy must provide institutional arrangements for small property owners to achieve the consolidations in 4 above. Included in this area of policy development are:

- a. Forest cooperatives
- b. Agencies for local forest development such as federal and state agricultural extension services
- c. Grant-in-Aid for start up of joint ventures
- d. Low interest loans for land exchanges and consolidations
- e. Re-examination of the financial support to existing agencies such as the Federal and State Forest Services to insure their existing skills and experience are made available to each and every private forest landholder.

6. A national policy must be developed towards improved applied research in the area of increasing productivity of marginally productive forest land. Both Federal and private research agencies have tended to apply their knowledge to the controlled environment of the large centrally managed forest tract. That knowledge must be applied to the small landowner or his desire to consolidate will shrivel due to his feeling of technical inferiority. Some of the more important areas of research to be developed are:

- a. Genetic research designed to promote the proper forest strains for the appropriate local environment. Incentives must be provided to apply the knowledge.
- b. Management practices for small tracts must be developed through research.
- c. Insect and disease research particularly in regard to small tract treatment.
- d. Applied research to develop improved mechanized systems of planting, maintenance, and harvesting of small forest areas. Of particular importance is the development of small scale, low investment machinery for such tasks in order to reduce the capital necessary for such mechanical systems until such time as cooperative forest consolidations become operative as indicated in 5 above.
- e. Centers for the aforementioned types of research must be regionally developed under federal guidance.

7. A national policy of research funding in geographic regions in accordance with potential productivity is highly desirable in support of 6 above.

II. PROVISIONS FOR MULTIPURPOSE UTILIZATION OF FOREST LANDS OR

PROVISIONS FOR "CASUAL" AMENITY LANDS IN AREAS OF

RESTRICTED SINGLE PURPOSE FOREST AREAS

Multiple use concepts for public and corporate forest lands have received great past and current emphasis. In such controlled environments, a great deal of experimentation has been performed. Development of concept and experimentation on fragmented independent forest tracts have not received such needed attention. The following policies are, therefore, recommended:

1. Research in the area of zoning of rural lands should be performed to determine if such a policy might be feasible on a local or regional level. This research might be performed in conjunction with the national need for rural re-examination currently being publicized. (The Wisconsin program, in this respect, should be examined.)

2. Should cooperative consolidation of forest lands be brought about as a result of policies proposed in I above, then a national policy should be developed regarding comprehensive planning for land use in regard to both

corporate and consolidated private forest tracts. Recreational, wild life refuge, pollution suppression and other varied multiple use concepts should be built into this comprehensive planning system for these environments.

3. In areas where large tracts of single purpose forests exist, the federal government should foster a policy that would establish a system of "casual" amenity lands for public use. Such lands would be leased from private owners who should be granted tax relief on such lands and should further be released from liability while such lands suffer public use. Opening up to 25% of the marginally productive privately held forested areas to such public use could be funded by the government with a codicile that 50% of the proceeds gained by the private land holder in this program must be used to upgrade their remaining forested lands to become a competitively productive source of forest materials. (The U. S. Forest Service or typical Department of Agriculture institutions could effectively develop programs to execute such a policy.)

III. INCREASED UTILIZATION OF RESIDUES FROM FORESTS AND FOREST PRODUCT INDUSTRIES

At the present time, approximately 35% of the forest raw material at the cut stump is discarded in the process of rendering the material to a finished forest product in the consumer's possession. This tremendous wastage has been allowed to exist due to economic and technological constraints. When one considers national need, improved processes for material recovery, energy recovery, and even chemical recovery are imperative. The following policies are, therefore, recommended:

1. As approximately 40% of such wastage occurs as primary manufacturing residue, a national policy of industrial incentives must be promoted to finance research and development of systems that would use such residues to reduce material, energy, or chemical demands on non-renewable material usage. Manufacturing industries generally have the technological ability in their controlled environment to perform their task.

2. However, in the more loosely controlled environment of the forest lands, a heavily financed federal program of research and development of residue salvage and utilization systems may be the only sensible national policy. Such research, both basic and applied, should explore the possibilities of:

- a. Small scale, easily transportable energy converters which would use residue as fuel.
- b. Development of products made exclusively from low quality residue materials, in particular, bark.
- c. Creation of systems for residue conversion to uniform quality raw material without economically constraining existing harvesting or production systems.

- d. Broadening specie utilization in conventional forest product manufacturing processes.
- e. Use of forest residues as adjacent materials in recycling systems (Sec. IV, hereafter).
- f. Bark-wood separation in on-site chipping operation.

3. One of the first requisites of such research should be a national survey of residue availability. Unless amounts and locations of such previously discarded residues become available these will be no means of rendering the research and development noted above to commercial practice. Inventories of residues must be identified.

4. Upon successful completion of 2 above, it may then be desirable to prescribe a national policy of incentives and/or penalties in reference to residue utilization efforts made by harvesting and manufacturing entities.

IV. ENHANCING THE POTENTIAL FOR RECYCLING OF FOREST PRODUCT MATERIALS

Although recycling of cellulose fiber products has been practiced for many years in the paper industry, economic constraints have prevented any percentage growth in their approach to conservation of material. Even though forest products are generally biodegradable, increasing attention should be paid to the recycling process to reduce the burden of disposing of forest products and the demands upon the forest. Therefore, the following policies are recommended.

1. In consort with other material recycling research, consideration must be given to a national policy for establishing preferential treatments for collection, sorting, and segregation enterprises in all local solid waste collection systems. It is apparent that the recovery and recycling of materials non-renewable in nature are undergoing increased research and developmental considerations at this time. It should become a national policy that used cellulose collection and recycling systems should receive the same attention even though the forest product materials are renewable in nature over time.

2. A national re-examination of freight rates and freight rate making practices should be conducted to insure that secondary forest related products are recyclable wastes do not suffer a disadvantage in support of primary product rate advantages.

V. DEVELOPMENT OF NEW PRODUCTS FROM FOREST RAW MATERIALS, PARTICULARLY IN
REGARD TO REPLACEMENT PRODUCTS FOR EXISTING MARKETS NOW SERVED BY
NON-BIODEGRADABLE RAW MATERIALS AND
MATERIALS NON-RENEWABLE IN NATURE

In recent years, particularly in the construction and furniture industries, new materials with slight economic or technological advantages have replaced forest grown materials. Only recently have the material shortages and disposal problems raised their heads. The committee felt that reversal of past practices in these typical industries was desirable. In addition, a \$750,000,000 annual deficit in our balance of payments due to our failure to export our forest products also indicates that forest product marketing practices should be re-examined. Therefore, the following policy recommendations are made:

1. The federal government should foster a policy of recognition that, as forest products are generally biodegradable and are manufactured from raw materials which are renewable in nature, the highest priority should be attached to the research and development of such products which might replace products made from materials which are non-biodegradable and non-renewable in nature. A codicil of this policy would be the development of a system of penalties for the usage of non-biodegradable materials in the consumer area of "disposable" products. It should also be possible to develop a system of incentives for the usage of forest products as replacement for "non-disposable" products made from non-renewable raw materials. (Taxation of "disposable" products, and market research, product research, consumer research for generating acceptance of forest products in "non-traditional" uses are means of achieving these ends.)

2. There should be a national policy of recognizing those materials which consume the least energy during the transformation process from raw materials to finished product. Research on the subject should be disseminated on a broad scale to manufacturing enterprises so that they become aware of the possible savings accruing from proper raw material selection as energy costs rise.

3. Earlier manufacturing practices for forest products should be re-examined to see if they can again become competitive with the mineral and petrochemical manufacturing processes which may have displaced them. This type of research is more properly done by private industry, but government incentives should be forthcoming if new renditions of old practices enable replacement products to appear in the market, thus, relieving other more critical material shortages.

4. Federal home construction programs of many varieties should require re-examination of forest products usage in the housing industry where the competitive economic disadvantage is not substantial.

5. A special policy should be determined for research and development in the usage of hardwood materials from low quality hardwood forests in this country. It is highly desirable to reduce such acreage in some parts of the country, if only so renewable stands of softwoods can be grown in their place. Therefore, if such hardwoods are only harvested for their energy potential, actual national advantage may accrue. In mixed quality hardwood forests clearcutting and regeneration in softwood could actually, for a short time, reduce the import of quality hardwood now necessary for the furniture industry.

6. Private forest product industries should be mandatorily directed by government to re-examine their attitude towards export of those forest products which are competitive in world trade. In many instances certain forest products are not now marketed in volume for export because they would then compete successfully with more profitable wholly or partially owned foreign subsidiaries.

7. Should a Value Added Tax become a national policy, then tax reliefs for exported products may become a method to stimulate economic acceptance of 6 above.

VI. EDUCATION OF THE PUBLIC CONCERNING ITS RELATIONSHIPS WITH THE FOREST AND THE PRODUCTS DERIVED THEREFROM

It is apparent that the public and, in particularly, vocally active special interests within the public have conflicting views with forest management and forest product manufacturers. This is a symptom of our times. To overcome the illogical differences through dissemination of knowledge is a respectable goal for a national material policy group to consider. The following specific policies are, therefore, recommended:

1. The government must choose a national policy that is fair to private industry in regards to dissemination of information to the public. If government, at all levels, expects to maintain a free enterprise private industry system, it must be impartial in its educational processes and responsibilities, critical where necessary, yes, but supportive of the accomplishments which private industry does achieve.

2. Conflicting reports from diverse agencies responsible for material resources and the ecological impact of their use have, intentionally or unintentionally, confused the public to, in some instances, the point of fear. It is, therefore, suggested that centralization of national responsibilities for educational policy regarding material usage and its ecological import is mandatory.

3. A national policy should be formulated for the operation of the educational function in 2 above, based on substantial social research rather than reaction to minority viewpoints. Since our knowledge of "social

requirements" in most material resource areas is vague and incomplete, we need to develop better ways of determining these facts. Such research might include:

- a. Research on public attitudes towards use of forest lands. (Do people really think about growing trees in the same way they think about growing corn?)
 - b. Analysis of institutional arrangements and the benefits and costs accruing therefrom. Amenity costs in this type of research might result in offsets against economic costs.
 - c. Development of better mechanisms for reasonable effective public participation and input into the decision making process in the agencies and legislatures responsible for decisions about the use of forest resources and products.
 - d. Research into the attitudes of independent private forest landholders, particularly in regard to their willingness to become more productive and to open segments of their land to public use.
 - e. Determination of a national policy regarding the desirable use of public lands both privately, publicly, and corporately held.
4. A national program for dissemination of such educationally oriented research must be developed.

VII. EDUCATION OF THE LABOR FORCE NECESSARY FOR MORE PRODUCTIVE SYSTEMS IN FORESTRY AND FOREST PRODUCT INDUSTRIES

A shortage of labor in all aspects of forest product industries is noticeable today. This shortage is compounded by a skill shortage as mechanization replaces manual labor in field and factory. Academically restricted disciplines in the material resources field have failed to meet the need for broadly capable professional people in this field. The following policies are, therefore, recommended:

1. Interdisciplinary educational curricula should be developed for the training of materials resource management and engineers at university and professional levels. Cross fertilization between forestry, various engineering disciplines, sociologists, and economic managers would result in a cadre of skilled professionals to implement and direct the policy recommendation contained herein.

2. While recognizing the further educational needs at the university or professional level, the government should, more importantly, foster the educational requirements of forest products industries at a much earlier stage in local educational programs. Recognizing that labor shortages exist in forest planting, maintenance, and harvesting processes and recognizing that increasing mechanization in these work areas require new skills of a technical or vocational level, and further recognizing that lack of wood-working skills in the construction and furniture manufacturing industries

have forced the use of non-biodegradable "substitute" materials; it, therefore, behooves government to recognize the need for technical or skill training in these areas through policy statement to private and state educational systems. (Funding recognized programs in these areas of labor or skill shortages through traditional educational institutions should, of itself, provide implementations of this policy.)

3. Educational activities must be enhanced for the current labor force in forestry and forest product industries, particularly in the areas of safety and adherence to existing regulatory requirements concerning their work environment. This becomes more critical as there exists a national policy to more rigidly enforce those regulations applying to the forest work environment.

4. After satisfactory educational opportunities have been developed by 3 above, then it behooves the governmental and regulatory bodies to uniformly enforce all manufacturing, consumer protection, transportation, ecological, and safety laws and regulations applicable to forestry and forest product industries.

A SUMMARY OF FORUM DELIBERATIONS

R. F. Hochman
Forum Chairman
Georgia Institute of Technology

It was an extremely difficult task to summarize the extensive information contained in the formal presentations and the hours of deliberation of the forum workshops. I have tried to use as much objectivity as possible in determining the major points which would be considered national policy matters. The most convenient way to summarize was to follow the program outline and present the major policy considerations in each of the four areas covered by the forum. In conclusion a number of major factors, seemingly common to all areas, are discussed.

I. MATERIALS DETERIORATION

In conflict with a projection of material requirements, is the extensive loss of resources due to deterioration of materials. The economic consideration of the direct national losses due to metallic corrosion alone is in the neighborhood of 15 billion dollars annually, five billion of which could be saved by the proper application of existing technology. Add to this the factors of public safety, contamination of product and environment plus lost time and the total corrosion loss becomes a major, but unfortunately lightly treated, national economic problem.

It is obvious that the proper application of materials by the exploitation of available knowledge and/or judicious research could result in extensive savings in materials resources so vital to the world's growing needs and limited supply.

Major policy matters resulting from the deliberations in this area were:

1. Establishment of a national committee or commission to evaluate deterioration and catastrophic failure of engineering materials in quantitative detail. An excellent example of such a study was recently performed in Great Britain by a panel of 20 experts contacting over a 1000 industries, technical societies, universities, research associations, and governmental agencies. The formation of an analogous, federally supported committee, is recommended to evaluate the total problem and consider remedial actions.

2. It is obvious that the present traditional engineering education is devoted to the development of a system or process to perform some function, but it neglects to a great extent the stability of the materials required in construction of this system or process. Often this has resulted in the misapplication of materials and the irrelevant use of handbook data. It is therefore recommended that a national educational policy in the engineering fields be implemented to provide engineers with the training needed in this area. Such an educational policy should include continuing education of practicing engineers and scientists and most of all provide industrial and governmental management personnel with an awareness of this costly and hazardous waste of materials.

3. The national approach to deterioration of materials is extremely fragmented. It includes several technical societies, federal and industrial research and several universities. A cohesive national policy based on the recommendations of the committee suggested in (1) above with a system of corrosion economics involving important tradeoffs, a systematic method to predict complex chemical-mechanical degradation and an index of reliability, is recommended. In addition to the control of degradation, procedures for recycling degraded materials must be evaluated in a systematic fashion.

II. TRANSPORTATION AND CONSTRUCTION MATERIALS

This group primarily devoted its deliberations to non-renewable resources, i.e., mineral aggregates, bitumen (asphalt), cement and metals. These materials are vital to sustaining and improving the present economic, social and political position of the country. It is important that the commission evaluate the continuing supply of these materials as well as identify the requirements for new materials to assure that the demand for public needs is met.

Basically these policy deliberations resulted in:

1. A policy suggestion for a national inventory of non-metallic mineral resources and materials used by the construction industry. Often shortages and construction shutdowns are due to the lack of specific materials; however, substitutions are available within the same category in other areas of the country. These shortages are due to distribution problems and more importantly the lack of communication and data on the availability of materials in other sections of the country. Therefore, it is recommended that a policy be established to identify and sustain an inventory of these materials for long-range planning and that an economical distribution system for vital construction materials be developed.

2. Important from a construction materials standpoint is a national land use policy. Many environmental problems plague the transportation and construction industry despite the fact that these industries recognize the problem. The major land use programs must consider water pollution, sediment control, air pollution, land disturbance, wildlife preservation and general unsightliness of construction.

A national policy should be developed to provide long range planning for optimal and systematic land utilization and growth of facilities which will impose minimal adverse environmental disturbances. This policy should assure the availability of construction materials that are extracted from the ground and the reclamation of land once the mineral has been depleted.

3. An educational policy in construction materials. No overall educational program exists in the area of construction materials other than fragmented sections in certain disciplines within universities, federal agencies and professional societies. Education of the public in the importance and limitations of construction material resources plus evaluation of a higher educational program in both engineering and social science related to the better utilization of construction materials is required. Finally manpower training and research related to the optimum use and development of new construction materials need to be implemented.

III. TEXTILES

It is obvious from examination of the textile statistics for 1971 that several problems exist with regard to the textile industry in the United States. One of the most obvious is the foreign trade deficiency in textiles, 2.08 billion dollars, which represents 13.7% of the U.S. total textile production. Low weekly wages for the textile workers, usually located in small towns or rural areas, has resulted in a rate of textile employee drop out nearly twice that of the labor force average in the United States. Many new types of textile equipment are being marketed in the United States but nearly all is of foreign development and origin. It is important then that certain factors be considered, particularly in aiding the small town textile mill to remain competitive and to develop new and improved facilities and for the country in general to regain its pre-eminence in this field.

Policy action suggested by the workshop:

1. It appears that interim policy action is required to limit the textile imports from countries with which we have no agreement. In the short term, this would necessarily be unilateral agreements with these countries. For the longer term the only satisfactory solution of the problem appears to be a multifiber, multination agreement similar to the long-term cotton agreement.

2. It is necessary to develop a policy to make the U.S. textile industry competitive with other nations. The diversity and division of the American industry into several thousand organizations of varying size indicates a cooperative program is required involving industry and government (similar to the type of program instituted in Japan) to develop applied research, education and dissemination of engineering and scientific technical material to increase productivity and quality. Centers of research and development,

teaching and communications should be established in conjunction with colleges and universities to provide technical support to industry.

3. Special assistance to the small producer to institute modernization and to use new technologies should be encouraged by governmental tax considerations and the availability of industrial improvement loans.

4. A national committee or commission be established to continuously evaluate the needs, growth and changes in the textile industry.

IV. FORESTRY AND FOREST PRODUCTS

It is obvious from the workshop discussions that a major consideration for more effective forest development is the small independent forest landowners who represent in excess of 50% of the forest land available. In addition, consideration must be given to the more effective use of the residues of the forest and forest product industry and the development of products with a potential for recycling.

General policy recommendations were as follows:

1. Property taxation based on actual land use rather than potential land use be implemented, and that general policy with regard to inheritance tax on forest lands be established. A federally established basis for a more uniform state forest taxation policy should also be considered.

2. A policy to establish cooperative type forest tracts for better management and control. This policy should not infringe upon the right of private ownership but should stimulate the desire for the independent private landholder to participate in a cooperative effort. This is all suggested on the basis of increasing the productivity of the small forest tracts owned and developed by independent private landowners.

3. It is important that an overall policy for enhancing the potential recycling of forest products be developed and that further research for new products, particularly for existing markets now served by non-biodegradable materials and materials non-renewable in nature. The forest is a wonderful materials source because of its renewability. In keeping with this trend, increased utilization of forest residues through research is extremely important to better use the total forest growth and effect better environmental control.

4. A policy of education to develop more productive systems for forestry and the forest products industry, particularly research to help the small independent landowner. Most federal and private researchers tend to apply their knowledge to controlled environments in large centrally managed forests. Important areas such as genetic research to promote better forestry management practices, new types of disease control research in regard to

small tract treatment and engineering developments for planting maintenance and harvesting of small tracts should be thoroughly examined for maximum forest utilization.

V. CONCLUSIONS

Consistent throughout the deliberations were a number of basic facts which warrant strong consideration in national policy deliberations. Specifically they are:

1. The continued need for an assessment and evaluation of the availability and projected needs of materials, not just objective data from economic surveys, but a total evaluation of specific needs in light of sociological, ecological and conservation factors as well as availability to assure a continuing source of materials to preserve present living standards. It is obvious that the former methods of assessment of materials needs are passe.

To do this, it is suggested that there be a continuing commission on materials policy, with sub-committees in the major materials areas with members from industry, government, education and the general public.

2. Education. A policy in materials education is discussed in each of the sections as an important consideration for the near term as well as the future. Obvious lack of education in proper application of materials shows effectively the result of traditional engineering education which is geared to producing a product often neglecting the long term safety, conservation and environmental interaction of materials. Certainly a national policy with these educational considerations is vital to the future materials needs. The engineer and the scientist must interact with all levels of the socio-economic strata. This is a matter of national concern and vital national policy; as material resources diminish, indiscriminate obsolescence and misuse cannot be tolerated.

3. In the areas of construction materials and forestry, a uniform national land use policy appears to be the only effective way to provide environmental protection and rehabilitation of land.

4. It is extremely important that we conserve our materials by better application and effective substitution. This must be an important federal and public management policy.

APPENDIX A

NATIONAL COMMISSION ON MATERIALS POLICY FORUM

FORMAL PROGRAM

June 26, 1972

9:00 A.M.	MEETING--Room 5 Space Sciences Building. Presiding, Dr. Robert F. Hochman, Forum Chairman, Georgia Institute of Technology
9:00 A.M.	<i>Welcome</i> --Dr. Vernon D. Crawford, Vice President for Academic Affairs, Georgia Institute of Technology
9:05 A.M.	<i>Purpose and Goals of the National Commission on Materials Policy</i> --Dr. James Boyd, Executive Secretary, National Commission on Materials Policy
9:20 A.M.	<i>Forum Background and Purpose</i> --Dr. Robert F. Hochman, Professor and Associate Director for Metallurgy, School of Chemical Engineering, Georgia Institute of Technology
9:30 A.M.	<i>The Assessment of Materials Limitations and Recommended Course of Action</i> --Dr. Roger W. Staehle, International Nickel Professor of Corrosion Science and Engineering, Ohio State University
10:30 A.M.	<i>Break</i>
10:50 A.M.	<i>Deterioration of Synthetic Plastics and Recycling</i> --Dr. W. L. Hawkins, Bell Laboratories
11:20 A.M.	<i>Transportation and Construction Materials--Problems and Requirements</i> --Dr. William A. Goodwin, Dean for Research, University of Tennessee
12:05 P.M.	<i>Nonmetallic Minerals of Construction--A Situation Report</i> --Mr. James D. Cooper, U. S. Bureau of Mines, Atlanta, Georgia
12:30 P.M.	<i>Lunch</i>
2:00 P.M.	<i>Reconvene</i> --Presiding, Dr. Thomas E. Stelson, Dean, Engineering College, Georgia Institute of Technology

- 2:05 P.M. *Textiles, U.S.A. in the 80's*--Dr. John L. Lundberg,
Calloway Professor of Textile Engineering, Georgia
Institute of Technology
- 2:35 P.M. *Forest Management and Land Use Conflicts: A Case
Study of Resource Management and Social Optimums*--
Ms. Elizabeth Peelle, Oak Ridge National Laboratories
- 3:05 P.M. *Forest Residue Utilization*--Dr. John I. Zerbe,
Director of Forest Products and Engineering Research,
U.S. Forest Service, Washington, D. C.
- 3:40 P.M. *Break*
- 4:00 P.M. *The South's Third Forest*--Mr. Donald W. Smith, Chief
Forester, Southern Forest Institute
- 4:30 P.M. *World Import Functions for the Paper Industry*--Dr.
C. G. Alexandrides, Professor of Economics, Georgia
State University

June 27, 1972

- 9:00 A.M. *Pre-Workshop Meeting*--Student Center Theater. Pre-
siding, Dr. Robert F. Hochman, Forum Chairman,
Georgia Institute of Technology
- Background and Charge to Workshops*--Dr. James Boyd,
Executive Director, National Commission on Materials
Policy. *Workshop Assignments.*
- 9:45 A.M. *Convening of Workshops*--Rooms 319, 320, 321, 333,
Student Center Building
- Workshop I--*Materials Deterioration*
Chairmen--Dr. Roger W. Staehle, Ohio State University
 Dr. John D. Muzzy, Georgia Institute of
 Technology
- Workshop II--*Transportation and Construction Materials*
Chairman--Dr. William D. Mazanti, Georgia Institute of
 Technology
- Workshop III--*Textiles*
Chairman--Dr. Winston C. Boteler, Georgia Institute of
 Technology

Workshop IV--*Forestry and Forest Products*
Chairman--Dr. Nelson K. Rogers, Georgia Institute of
Technology

10:30 A.M.	<i>Break</i>
10:50 A.M.	<i>Reconvene Workshops</i>
12:30 P.M.	<i>Lunch</i>
2:00 P.M.	<i>Reconvene and Realign Workshops</i>
3:30 P.M.	<i>Break</i>
3:50 P.M.	<i>Reconvene Workshops</i> Preparation of Drafts of Workshop Working Committees

June 28, 1972

9:00 A.M.	<i>Full Meeting of Forum Participants--Student Center Theater</i>
9:15 A.M.	<i>Reconvene Workshops To Review Drafts</i>
10:30 A.M.	<i>Break</i>
10:50 A.M.	<i>Full Meeting of Forum Participants--Student Center Theater. Reports of Workshops. Discussion and Comments.</i>
12:30 P.M.	<i>Adjournment.</i>

APPENDIX B

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